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ABSTRACTS OF DOCTORAL DISSERTATIONS

Accepted July 1, 1953 - June 30, 1954

These abstracts are arranged in alphabetical order by names of the authors. The first page of each abstract carries also the serial number of the dissertation, the date of acceptance of the thesis by the Graduate College, the name of the chairman of the student's committee, the degrees held by the author, and the candidate's academic position (if any) in the several research institutes of Iowa State College.

The following summaries and indices may prove helpful to those interested in tabulations and to those who wish to examine groups of abstracts of theses in the same or related fields.

1. DOCTORAL DISSERTATIONS ACCEPTED JULY 1, 1953 - JUNE 30, 1954 = 146.
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 a. Institutions other than Iowa State College - 119.
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2. INDEX TO THESES BY DEPARTMENTS. Double indexing is used in those cases in which two departments are jointly responsible. The departments are arranged alphabetically. Under each department are listed alphabetically the names of the authors.

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3. INDEX TO THESES BY RESEARCH INSTITUTES THAT PROVIDED RESEARCH FACILITIES. A graduate school can function only where there are adequate opportunities for research. The existence on the campus of Iowa State College of six research institutes well integrated into the college programs is in large measure responsible for the growth of the graduate work. These institutes have frequently assumed the responsibility of providing research facilities necessary for the doctoral candidates in their respective fields. It is obvious that these institutes carry on a significant fraction of their researches by use of workers who are in a sense apprentices of research. Under the name of each institute is given the total number of theses for which research facilities were afforded, and an alphabetical list of the authors of sponsored theses.

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SUBSTITUTION RELATIONSHIPS BETWEEN FORAGE AND GRAIN IN MILK PRODUCTION[1]

CARL WENDELL ALLEN[2]
Department of Economics and Sociology

Three distinct but related production functions (regression equations) were studied in order to derive estimates of the substitution rates between forage and grain in producing milk. Contour (equal product) equations were derived from two of the production functions to indicate the various combinations of grain and forage required to produce a given quantity of milk under specified conditions of inherent ability and geographic location. Contour "maps" of milk production computed from the more complex production function are shown for five situations ranging from (1) a low inherent ability cow at a low station to (2) a high inherent ability cow at a high station. These contour maps indicate that the rate of substitution between forage and grain is different for various points on any given contour and that the rate of substitution varies between contours.

The majority of the contours indicate a diminishing marginal rate of substitution of forage for grain in milk production. A portion of the contours in the middle area of the date have a negative slope (concave to the origin) and do not conform to production logic. The conclusion is that the negative contours were due to the nature of the production function fitted and that the true relationship between grain and forage in the area of the negative contours is approximately linear.

The first two production functions (regression equations) extended the number of independent variables by interaction terms and polynomials of the three original independent variables-inherent ability, forage consumed, and grain consumed. The third and more complex production function introduced a new concept by bringing estimates of the dependent variable from an earlier analysis into the right hand side of the equation as independent variables. Both linear and quadratic expressions of this estimate of the dependent variable were included to allow the contour value to vary with contour height. The reduction in the error sum of squares for this special method was considered significant. The method merits consideration in other problems where the rate of substitution between factors is a function of level of output.

It is not argued that the estimated forage-grain combinations (and subsequent substitution rates) are the final answers. Perhaps the precise substitution rates between forage and grain await data from further experiments designed specifically for the problem.

[1]Doctoral thesis no. 1558, submitted June 7, 1954. Chairman of Committee, Earl O. Heady, Department of Economics and Sociology.

[2]B.S., University of Kentucky, Lexington, Ky., 1939. M.S., Ibid., 1941. Research Assistant.

CHARACTERIZATION OF SOIL PHOSPHORUS BY EXCHANGE RESIN ADSORPTION AND P^{32} EQUILIBRATION[1]

FATHI MOHAMED AMER[2]
Department of Agronomy

The ultimate objective of this investigation was to develop a method for estimating the availability of soil inorganic phosphorus to plants through the use of an anion exchange resin. An investigation of phosphorus adsorption from solutions by the resin Dowex 2 showed that small quantities of phosphorus were adsorbed almost quantitatively over a pH range covering that encountered in agricultural soils. Where complete removal was not attained a percentage of the added phosphorus was removed. Further, the rate of phosphorus removal by the resin was found to be controlled by the concentration of phosphorus at surface of the resin particles, and not by a resin characteristic such as

[1]Doctoral thesis no. 1428, submitted June 22, 1953. Chairman of Committee, C.A. Black, Department of Agronomy.

[2]B.S., Fouad I University, Egypt, 1944. M.S., Iowa State College, Ames, Iowa, 1949. Graduate Assistant.

internal diffusion. These results indicate that with a sufficient number of resin particles in an agitated aqueous suspension of soil and resin, the rate of phosphorus removed by the resin should be a measure of the rate of phosphorus release from soil.

In experiments with soil, the rate of phosphorus adsorption by the resin was measured by determining the phosphate content of the resin after wet sieving to eliminate the soil. It was found that phosphorus removal by resin adsorption increased with the ratio of resin to soil up to a value of 1:1 by weight. A further increase to a ration of 2:1 resulted in no further increase in phosphorus removal. Thus, beyond a ratio of 1 part of resin to 1 part of soil, the rate of phosphorus removal from the soil was presumably independent of the ratio and instead was a function of the rate of release from the soil.

Phosphorus removed from soil by the resin increased with time, rapidly at first and then more slowly. A similar behavior was obtained by measuring the rate of exchange between soil phosphorus and P^{32}. The quantities of soil phosphorus adsorbed by the resin during a given time were below the quantities equilibrated with P^{32} during the same interval of time. The numerical values are nevertheless remarkably similar in comparison with the wide differences in absolute values commonly obtained by conventional tests for soil phosphorus availability. It appears that the similarity in numerical value obtained by the two processes results from their similarity in action and their independence of the accessory characteristics of soils. Both methods involve exchange of soil phosphate and some other anion. It is presumed that with each method the rate of exchange is a function of degree of dissociation of the phosphate and accessibility to the solution.

When the data for the amount of soil phosphorus adsorbed by the resin after different intervals of time were plotted on a log-log scale, the rate curve for each soil became two straight lines. This behavior suggests the existence of two distinct reactions differing in rate. The time at which the lines intersected was found to range from 56 to 90 minutes.

The values of resin-adsorbed phosphorus for estimating availability of soil inorganic phosphorus was investigated using a group of 16 soils. One gm. of Dowex 2 resin of > 32-mesh size was shaken 2 hours with 1 gm. of < 100-mesh soil and 100 ml. of water. The resin was then separated from the soil by pouring the suspension through 82-mesh sieve cloth. To extract the adsorbed phosphorus, the separated resin was leached with 10 per cent sodium chloride solution.

The values for phosphorus adsorbed in 2 hours gave a correlation of 0.94 with Fried and Dean "A" values obtained in a greenhouse experiment. The correlation between the Bray test and "A" values was 0.87. The high correlation between resin-adsorbed phosphorus and "A" values suggests that the phosphorus measured by this technique provides a good estimate of the availability of soil phosphorus to plants.

GENETIC RELATIONS BETWEEN CARCASS CHARACTERS, RATE AND ECONOMY OF GAIN IN SWINE[1]

DAVID E. ANDERSON[2]
Departments of Animal Husbandry and of Genetics

This study was undertaken (1) to measure the effects that certain extraneous factors had on carcass composition (2) to obtain estimates of heritability and (3) to obtain estimates of phenotypic and genetic correlations between rate and economy of gain with carcass composition, particularly the correlations between rate and economy of gain and carcass fatness.

The data were based on the feed and gain records and carcass yields and measurements of 550 pigs fed in the Record of Performance feeding trials at the Iowa Agricultural Experiment Station. The pigs from which data were obtained included 41 Poland-China and 14 Landrace inbreds, 94 Poland-Landrace crossbreds, 167 Poland linecrosses, 168 Poland multiple linecrosses and 66 multiple crossbred pigs. These were from 344

[1]Doctoral thesis no. 1518, submitted March 15, 1954. Chairmen of Committee, John W. Gowen, Department of Genetics, and L.N. Hazel, Department of Animal Husbandry.

[2]B.S., University of Massachusetts, Amherst, Mass., 1950. M.S., University of Connecticut, Storrs, Conn., 1952. Graduate Assistant, Agricultural Experiment Station.

litters and 195 sires. The data were corrected for differences in sex and carcass weight, i.e., to a basis of barrow carcasses weighing 165-169 pounds prior to the analyses of variance and covariance by constants obtained from a least squares analysis.

Males were 0.2 inch shorter in body length and 0.1 inch longer in leg length than females. Males also yielded 1.2 percentage points more of fat cuts, with 0.2 inch thicker backfat than that of females. Males also yielded 1.4 less percentage points of lean cuts but weighed 8.3 pounds more at 154 days of age than females.

Weight increases caused a response in all the carcass traits. A five-pound increase in carcass weight resulted in an average increase of 0.18 inch in body length, 0.11 inch in leg length, 0.73 per cent more fat cuts, 0.18 inch of backfat and per cent lean cuts decreased 0.55 per cent. These changes in carcass composition with weight attained high statistical significance.

The components of variance for litters and litter mates were indicative of a consistent but varying maternal environmental influence affecting all traits, but being most extreme for per cent of lean cuts and rate of gain. The components were also indicative of maternal and individual environmental influences being roughly in the same proportion for the various traits.

Estimates of heritability of within line differences in a population inbred no more than the foundation stock from which the lines were derived were as follows:

Body length	0.48
Leg length	0.73
Per cent of fat cuts	0.69
Backfat thickness	0.40
Per cent of lean cuts	0.15
Economy of gain	0.26
154-day weight	0.19

Dominance and maternal environmental influences were considered to have an important effect on per cent of lean cuts and rate of gain. Body length was affected more by maternal and individual environmental influences than leg length. Backfat thickness was affected very little by maternal influences but considerably by environmental effects. The estimate for feed economy was considered only an approximation.

The genetic correlations between 154-day weight and per cent of fat cuts, backfat thickness and per cent of lean cuts were 0.56, 0.02, and -0.26, respectively. Those between feed economy (feed requirements) and the same traits were 0.05, -0.15, and 0.28, respectively. These correlations indicate that the genes responsible for rapid and economical gains in swine are concerned with increasing fat deposition and decreasing leanness slightly. Consequently, effective selection for rapid and economical gains would result in slightly fatter carcasses than if gaining ability and fatness were not associated genetically.

Possible methods of circumventing the relation between fatness and gaining ability are as follows: (1) to base selection more on feed economy (low feed requirements) than on rate of gain since the genetic correlations between the former trait and fatness were considered to be smaller than those between rate of gain and fatness; (2) to practice selection for rate of gain at 112 days of age when bone and muscle growth are more pronounced than fat growth; (3) to practice selection for rate of gain at 154-day weight and against backfat thickness as determined by a "probing" technique; (4) to base selection on a selection index utilizing a proper weighing of the above factors along with an indication of dam productivity, body length and other factors measurable on the live animal; and (5) to develop new combinations of genes by the judicious crossing of lines and breeds.

EVALUATION OF CATALYSTS FOR HYDROCARBON OXIDATION[1]

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Department of Chemical Engineering

The partial oxidation of propane to useful organic chamicals is economically attractive, with products possible which are worth from 6 to 22 times the cost of the raw materials. Present commercial processes use a combination of high temperatures and pressures to produce a mixture of products. Previous investigators have been troubled with temperature control and with the reaction proceeding to form carbon monoxide and carbon dioxide.

The present investigation was carried out to evaluate catalysts which might provide a high yield of useful organic products, preferably with one compound predominating. The reaction was carried out in a fluidized catalyst bed to improve temperature control. Oxygen was used as the oxidizing gas for the reaction carried out at essentially atmospheric pressure.

The apparatus used consisted of equipment to meter and preheat separately propane and oxygen, a 2-inch pipe reactor to contact the gases with the catalyst and a condenser and absorbers to collect the products.

Thirty-one runs are reported, including twelve using Celite, and from one to three runs each on V_2O_5-K_2SO_4-silica gel, silica-alumina, activated alumina, CuO-Celite, La_2O_3-Celite, CeO_2-Celite, and MoO_3-Celite. The runs were made at flow rates from 3000 cc. per minute to 6500 cc. per minute (14.7 pounds per square inch absolute, 70°F.), with oxygen concentrations from 10 per cent to 30 per cent and temperatures from 650°F. to 950°F.

The best catalyst investigated was MoO_3-Celite, which converted from 6.1 to 9.5 per cent of the oxygen fed to useful organic products. These products consisted of 70-80 per cent aldehydes and ketones, 20-25 per cent alcohols, and 2-6 per cent acids. The per cent of the oxygen reacted converted to useful products in the presence of MoO_3-Celite was also higher than that with any of the other catalysts. In one run with MoO_3-Celite catalyst, the estimated conversion of fresh carbon feed, based on the recycling of all unreacted propane, would be about 38 per cent to useful organic products, 19 per cent to oxides of carbon, and 43 per cent to unsaturated hydrocarbons.

Operating the reactor without catalyst produced yields up to 7.0–13.4 per cent of the oxygen fed converted to useful organic products. The distribution of products was similar to that obtained with MoO_3-Celite.

Conversion of the oxygen fed to all types of products was greater with activated alumina, silica-alumina, and CeO_2-Celite than without a catalyst present. The other catalysts produced less total conversion of oxygen than was done without a catalyst present.

The fluidized bed apparatus was found capable of handling the large heats of reaction of the oxidation, providing the heat was not released immediately at the bottom of the bed.

[1]Doctoral thesis no. 1471, submitted November 11, 1953. Chairman of Committee, G. H. Beyer, Department of Chemical Engineering.

[2]B.S., New Mexico College of Agricultural and Mechanic Arts, State College, N.M., 1948. M.S., California Institute of Technology, Pasadena, Calif., 1952. M.S. Iowa State College, Ames, Iowa, 1950. Graduate Assistant, Engineering Experiment Station.

CULTURAL AND HARVESTING PRACTICES AFFECTING SEED YIELDS OF BIRDSFOOT TREFOIL, LOTUS CORNICULATUS L.[1]

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Broadleaf birdsfoot trefoil, Lotus corniculatus L., is comparatively new as a forage legume in North America. In the last decade much has been said in its favor for use in improving permanent pastures in the humid and sub-humid northern United States.

One of the major limiting factors in the use of domestic birdsfoot trefoil is the low yield of seed. Two reasons, inherent in the plant, have been major contributing factors, namely indefinite flowering and ripening of pods and the shattering of seeds from ripened pods. Observations show that seed pods are produced profusely, therefore seed yields potentially could be high.

The purpose of this investigation was to study basic factors in seed and pod development as related to stage of maturity for harvesting, to measure seed losses caused by pod dehiscence during harvesting and curing, and to isolate other factors related to seed yields. Experiments with the Empire strain were conducted from 1949 to 1952 at the Southern Iowa Pasture Farm in Monroe County, Iowa, and in 1952 and 1953 at the Agronomy Farm, Ames, Iowa, to study these factors.

Detailed studies on the development of the pods and seeds show that maximum pod length was attained within twenty-one days following fertilization. Definite changes in pod color were noted during maturation. The waxy, deep green color of the pods changed to purple about one week following full bloom, a week later it was dark green and then watery, light green about three to three and one-half weeks following full bloom. After three or four additional days, the pods changed to an oily, light brown color. In subsequent four day intervals, pods changed to dark brown and then black, respectively. Umbels set early in the season produced more pods and usually more seeds per pod than those set later in the season.

Seeds attained morphological maturity within twenty-seven days following full bloom. At this time the pods were light brown in color. Seeds harvested from light green, light brown, dark brown, and black pods were of high quality in regard to germination and size. Seed yields at these color stages were similar. Dark green pods were immature, had less viable seeds, and yielded less than pods more advanced in maturity. From this phase of the study it may be concluded that birdsfoot trefoil should be harvested when the maximum number of pods are light brown in color to obtain high yields of good quality seed.

Seeds normally ripened on the plant have a high percentage of hard seeds. Hard seed content was greatly reduced by threshing and scarification.

Spring and early summer clipping of birdsfoot trefoil greatly reduced seed yields in comparison with unclipped stands.

Birdsfoot trefoil produced more seed per acre when grown in association with Kentucky bluegrass, orchardgrass, and timothy than when grown alone. Larger seed yields were obtained in association with Kentucky bluegrass than with orchardgrass or timothy. Fewer birdsfoot trefoil plants remained in the stand two years following establishment when grown alone than when grown in association with either of the grasses. Increases in seed yield, however, were attributed to reduced lodging effected by the grasses, especially Kentucky bluegrass.

In a limited trial, the use of chemical defoliation increased pod dehiscence and was not generally satisfactory.

Seed losses from pod dehiscence either prior to harvest of mature stands or in mowed and curing herbage were found to be high if relative humidity dropped below 50 per cent. Seed losses were higher during swath curing than during windrow curing and increased progressively as the herbage dried.

The data from this study show that high seed losses may be expected when birdsfoot trefoil is harvested later than necessary (pods light brown in color). But even when harvested at the proper stage of maturity, seed losses due to pod dehiscence may occur in the swath or windrow when the relative humidity falls below 50 per cent. The most

[1]Doctoral thesis no. 1509, submitted March 9, 1954. Chairmen of Committee, W.H. Bragonier, Department of Botany and Plant Pathology, and I.J. Johnson, Department of Agronomy.

[2]B.S., Michigan State College, East Lansing, Mich., 1946. M.S., Ibid., 1949. Instructor

effective way to increase seed yield is by growing birdsfoot trefoil with a grass and especially with Kentucky bluegrass. In addition, from the results of this study, it is indicated that seed production of this legume may be limited to areas where high relative humidity is prevalent at harvest time.

SOLVENT EXTRACTION OF MEAT AND FISH OFFAL[1]

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The application of solvent extraction to the removal of oil from vegetable oil seeds has been extensively studied, but similar investigations have not been carried out on either meat and bone scrap or fish meal. Meat and bone scrap is the dry cooked waste from meat packing operations, whereas fish meal is the wet cooked scrap from the fish industry. The tallow obtained from the meat offal is used in the manufacture of soap and the residue is used as a hog feed supplement. The oil removed from the fish offal is used for paint and varnish and the residue is used as a poultry feed additive.

The two raw materials, meat and fish offal, were investigated to determine the effects of the various operating variables on the solvent extraction of them and the requirements for the successful processing of these in the Iowa State College extractor. These studies were carried out both in glassware in the laboratory and in a pilot plant model of the Iowa State College continuous countercurrent extractor.

The variables that were investigated in laboratory rate extractions were temperature, moisture, particle size, and the effect of wetting agents. In the pilot plant the effects of miscella concentration, extraction time, temperature, moisture, particle size, and wetting agents were studied. The solvent used in most of the work was trichloroethylene although some pilot plant data were obtained with commercial hexane.

In the pilot plant extractions, it was found that extraction efficiencies as high as 91.6 per cent and 98.3 per cent are attainable for fish and meat offal, respectively. In conformity with general opinion, trichloroethylene was found to extract more fat or oil than hexane in a given extraction period and was, therefore, the preferred solvent.

From the study of the effects of the various operating variables on the extraction of meat offal, it appeared that the extraction did not take place by a diffusion mechanism but solely by a washing process. This postulate was supported by the fact that there was little change in the miscella concentration in the horizontal section of the extractor and that extraction times in excess of 25 minutes did not reduce, within the limits of experimental accuracy, the residual extractables.

A similar study for fish offal showed that the extraction process although mainly a washing operation had coupled with it a diffusional process that was effective for extraction times in excess of 25 minutes.

The effect of temperature was greater in the pilot plant than in the laboratory for the extraction of meat and fish offal. This was believed to be due to the greater effect of temperature on the viscosity and density of the miscella. In the laboratory these effects are much smaller since the miscella is almost pure solvent.

Moisture was found to have a profound effect upon the extraction of meat and fish offal in the laboratory. For meat and bone scrap, the effect of moisture data gave a minimum residual extractable at a moisture of 7 per cent. With fish meal, the minimum occurred at a moisture of 20 per cent. Some of the fish meal tested in the laboratory had a moisture content as high as 45 per cent and it was found that wetting agents improved the degree of extraction. In the pilot plant, the improvement due to wetting agents was not confirmed.

A possible relation between laboratory and pilot plant data was suggested for meat and bone scrap, but inadequate data were available for fish meal for complete confirmation of this correlation. The relation was not found to hold for the extraction of cottonseed.

[1]Doctoral thesis no. 1500, submitted January 9, 1954. Chairman of Committee, L. K. Arnold, Department of Chemical Engineering.

[2]B.S., Iowa State College, Ames, Iowa, 1943. M.S., Chrysler Institute, Detroit, Michigan, 1947. Graduate Assistant, Engineering Experiment Station.

In the study of meat offal, it was discovered that the satisfactory operation of the pilot plant extractor was attained only if the bones were removed from the extractor at its lowest point. The addition of a settling chamber and a continuously operating screw proved to be inadequate for the bone removal.

STATISTICAL APPROACH IN PLANNING PRODUCTION PROGRAMS FOR INTERDEPENDENT ACTIVITIES[1]

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Recently developed techniques of input-output analysis and linear programming can be used for planning production programs at the level of a firm, an organization, or an economy. In this dissertation it was proposed to develop statistical procedures to predict the deviation of the outputs realized from the amounts planned, if the technological relationships between inputs and outputs (the input coefficients) used to apply these techniques, were liable to vary at the time of production.

First of all, it is shown that a nondegenerate solution of a programming problem occurs as a solution of m nonhomogeneous linear equations in m variables; in matrix notation:

$$\underset{(m\cdot m)}{B}\ \underset{(m\cdot 1)}{X} = \underset{(m\cdot 1)}{Q}\ .$$

The elements of matrix B represent the input coefficients. The elements of vector X represent the planned levels of activities (productive or disposal) which enter in the production program. Q is an m-column vector of constant elements. It is assumed that, at the time of operation of the program, the above model may be subject to certain random errors. In matrix notations, the model in operation may be represented as $(B + b)X = (Q + \varepsilon)$ where the elements of the $(m \cdot m)$ matrix b and the m-column vectors ε are small random errors. The problem thus reduces itself to finding approximate probability distributions of the elements of X, if the elements of b and ε have known probability distributions.

It was also proposed to derive the probability distributions of a linear function of the elements of X since it could be identified with the objective function which the program was expected to maximize.

At this stage the treatment is purely mathematical so that the results may be applicable in any other applied field. The problem is simplified by ignoring second and higher order cross-products of the errors involved in the expressions for a general element of X and a linear function of these elements. Then, with the assumption that the errors are normally distributed with means zero and known variances, the distributions for the general element of X and the linear function are derived. However, these distributions cease to be useful for practical purposes unless their cumulative distributions could be tabulated. This is difficult because of the nature of the probability distributions.

Some indirect procedures involving very convenient computations were presented to make statistical predictions. For example, one may obtain the 95 per cent confidence limits between which a particular element of X would fall. One may also compute the probability that the linear function of the elements of X will not be less than a prescribed number. In production economics these results seem to be very important. If the assumptions involved in this approach are approximately satisfied, one can compute, for example, the probability that the profit realized (if that is the objective function used in planning the program) will not be less than a particular sum of money. Also, in certain applications of linear programming techniques, one may obtain more than one optimum solution. The highest lower limit of the linear objective function, for the same confidence probability, will give a criterion for the choice among alternative programs.

[1]Doctoral thesis no. 1495, submitted December 15, 1953. Chairman of Committee, Gerhard Tintner, Department of Economics and Sociology.

[2]B.A., Punjab University, India, 1943. M.A., Ibid., 1945. Instructor. Cooperator, Agricultural Experiment Station.

An empirical example was presented in order to make an application of the above analysis. An optimum production program for a model family farm in Iowa, with fixed capital, land and labor resources, was determined.

Corn, soybeans, oats, flax, and wheat were the five crops considered. The relevant input coefficients were computed for each year separately, over the period 1928-1952. The average values were used as expected values in order to draw the optimum program. The production program, thus derived, included production of corn on about 79 acres and flax on about 64 acres, leaving about 5 acres of the total farm acreage (148) unused. The program was expected to yield 3464 bushels of corn, 687 bushels of flax and a gross monetary return of $8021 with the Iowa average prices during the year 1952.

To apply the probability approach for predicting the possible variations of these results, the unbiased estimates of the variances of the input coefficients relevant to the optimum program were computed from the corresponding series over the same period, 1928-1952. By the use of these estimated variances, the following 95 per cent confidence limits (with equal probability on either tail) were obtained:

	Lower limit	Upper limit
Corn (bushels)	2088	10282
Flax (bushels)	46	1625
Cross profit (bushels)	6298	18866

These results checked very closely with those obtained by the alternative procedure (cumulative distributions).

RESPONSE OF LACTOBACILLUS ARABINOSUS TO p-FLUOROPHENYLALANINE[1]

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Studies were made with Lactobacillus arabinosus to ascertain if p-fluorophenylalanine is incorporated into proteins of the organism under conditions in which this compound causes increased growth of the organism. In L. arabinosus at limiting concentrations of phenylalanine, subinhibitory quantities of the analogue were found to increase the amount of growth as compared to controls lacking the analogue. The amino acid composition of the organism was investigated since a hypothetical explanation for the increased growth was the substitution of p-fluorophenylalanine for phenylalanine in the proteins. Special procedures were instituted to remove free amino acids which might lead to erroneous conclusions if present.

L. arabinosus I (ATCC No. 8014) was grown on a synthetic medium for 48 hours at 37°C. In a typical experiment, 30 liters of synthetic medium contained 39.6 mg. of DL-phenylalanine and 98.9 mg. of DL-p-fluorophenylalanine. The cells were harvested by centrifuging and by repeated washing with physiological saline solution. A cytolyzate was prepared from the harvested cells by cytolysis with ether and sand.

In Experiment 1, the cytolyzate was treated with phenylisothiocyanate in 50 per cent aqueous pyridine at 37°C. This method was used to block the free amino acids in the cytolyzate, since such amino acids might be construed to be incorporated into proteins of the organism. The cytolyzate was refluxed with 6 N hydrochloric acid for 24 hours, and after removing the acid by distillation, the hydrolyzate was suspended in distilled water. Preferential adsorption of the aromatic amino acids was attempted by treating the hydrolyzate with activated charcoal. The amino acids were eluted with 20 per cent aqueous acetic acid containing 5 per cent phenol. The eluate was extracted with ether and concentrated. The pH was adjusted to 6. A portion of the solution was chromatographed on Whatman No. 1 filter paper. The solvent for the chromatograms was tertiary-butanol, methyl ethyl ketone, and water. The proportions were 4:4:1.5 by volume. Ninhydrin was used to locate the amino adid spots on the chromatogram. The results showed that p-fluorophenylalanine was present in the protein hydrolyzate of L. arabinosus I.

[1]Doctoral thesis no. 1474, submitted December 7, 1953. Chairman of Committee, Sidney W. Fox, Department of Chemistry.

[2]B.S., Purdue University, Lafayette, Indiana, 1949. M.S., Iowa State College, Ames, Iowa, 1951. Graduate Assistant, Industrial Science Research Institute.

Experiment 2 consisted of three controls for the phenylisothiocyanate treatment of cytolyzate. In this experiment, the cytolyzate was L. arabinosus I cells grown on a complete synthetic medium without the addition of p-fluorophenylalanine. In the first control, labelled G, p-fluorophenylalanine was added to the cytolyzate before treatment with phenylisothiocyanate. The cytolyzate was processed as in Experiment 1, and the chromatographic analysis indicated that the added p-fluorophenylalanine had been completely blocked by the phenylisothiocyanate. The results indicated that free amino acids could be removed by phenylisothiocyanate treatment.

Using a biological inhibition test for p-fluorophenylalanine, which is sensitive to smaller amounts than the ninhydrin reagent, a small amount of free p-fluorophenylalanine was present as indicated by a zone of inhibition. A mutant of the parent strain, L. arabinosus PT_1, which does not require an exogenous source of phenylalanine and tyrosine was used for biological assay.

In the third control, labelled I, no p-fluorophenylalanine was added to the cytolyzate. After treating the cytolyzate as G, the chromatographic analysis indicated that no other cellular constituents which react with ninhydrin have the same R_f value as p-fluorophenylalanine.

Since in Experiment 2, control G, the evidence from the biological assay indicated that the blocking of the free amino acids with phenylisothiocyanate was incomplete, two additional experiments were performed to check the result. In Experiment 3, p-fluorophenylalanine was treated with phenylisothiocyanate which was followed by treatment with 6 N hydrochloric acid. The acid was removed by distillation, and the pH was adjusted to 6. Quantitative paper chromatography showed that approximately 10 per cent of the p-fluorophenylalanine was not blocked by the phenylisothiocyanate treatment.

In Experiment 4, p-fluorophenylalanine was added to a cytolyzate of L. arabinosus I. The organism had been grown in a complete synthetic medium without p-fluorophenylalanine. The cytolyzate was treated with phenylisothiocyanate, and refluxed with 6 N hydrochloric acid for 24 hours. The hydrolyzate was processed as in Experiment 3. Good resolution of the hydrolyzate was not obtained by chromatography. The area in which p-fluorophenylalanine occurred was cut into four strips three-fourths inches wide and assayed by biological inhibition. The results indicated that 16 per cent of the p-fluorophenylalanine was present in the hydrolyzate.

In Experiment 5, the cytolyzate of cells, grown in the presence of p-fluorophenylalanine as in Experiment 1, was treated with concentrated hydrochloric acid at 37°C for 3 days to hydrolyze the proteins to peptides. A portion of the partial hydrolyzate was treated with phenylisothiocyanate and then hydrolyzed with 6 N hydrochloric acid in a sealed tube at 100°C for 15 hours. The acid was removed by evaporation, and the hydrolyzate neutralized with ammonium hydrozide. Paper chromatography failed to resolve the mixture of amino acids, but with the aid of biological assay the p-fluorophenylalanine was identified. Utilizing another portion of the partial hydrolyzate which was completely hydrolyzed with 6 N hydrochloric acid, the total amount of p-fluorophenylalanine was estimated by paper chromatography and by biological assay. In the cytolyzate, a total of 15 mg. of p-fluorophenylalanine was estimated to be present by paper chromatography and 12 mg. by biological assay. After phenylisothiocyanate treatment, 7.5 mg. of p-fluorophenylalanine were estimated to be present in the cytolyzate by paper chromatography and 9.7 mg. by biological assay. This corresponds to 50 per cent and 81 per cent recovery of the fluoro analogue which is present as amino-substituted p-fluorophenylalanine. The amount of the amino-substituted fluoro analogue recovered was greater than the 10 to 16 per cent expected from incomplete reaction with phenylisothiocyanate. Although values obtained by the two methods in Experiment 5 are not in complete agreement, the same qualitative conclusion that p-fluorophenylalanine is incorporated into proteins of L. arabinosus I can be deduced from each set of data.

EFFECTS OF SOIL CONSERVATION AND SOIL IMPROVEMENT PRACTICES ON FARM PROFITS AND MANAGEMENT[1]

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The specific objectives of this study were:

(1) To examine the relative erosion control of different practices and, if possible, to rate them on this basis.
(2) To indicate the difference in practices in terms of the conservation realized per dollar invested.
(3) To specify the implications of making payments for practices which are substitutes and those which are complements.
(4) To determine the cost of adopting various practices and the effects of their adoption on income from the acres on which the practice is applied and from the farm as a whole.
(5) To provide information on the capital required for conservation practices, the return on that capital investment over time and its relationship to the use and availability of credit.
(6) To illustrate the importance of whole farm planning in the establishment of an efficient and effective conservation program.

Experimental data from the Western Iowa and Page County Experimental Farms indicated that conservation practices differ in their effects on yield, their ability to control erosion and in costs of adoption. A very approximate and tentative ordering of individual practices, on the basis of their ability to save soil, follows. On slopes which exceed 12 per cent, lister contouring appears most effective followed by terracing, surface contouring and rotations in that order. On lower slopes, the order suggested by the data presented is terracing followed by lister contouring, rotations and surface contouring.

On rotations which do not include meadow, surface contouring and contour listing rank highest in terms of soil saved per dollar invested. On slopes of 2 to 20 per cent, contour listing combined with a rotation including first year meadow would, perhaps, give the greatest control of soil movement at least cost. Where contour listing is not advisable for a specific soil or location, surface contouring should be used instead. As compared to surface contouring, contour listing and rotations, terraces represent the most costly method of controlling erosion.

If practices are complementary, it means that used alone they do not conserve soil but give conservation results only if used in combination. In such cases payment should only be made for one and then only if the other practice is used in combination with it. If practices are competing in the sense that they represent alternative ways of accomplishing a specified level of erosion control, payments should be made only for one alternative.

Using three case farms in Western Iowa, ten livestock-crop programs were worked out for each over a 15-year period, 1952 to 1967. Assumptions were made of steady prices at the 1952 level and of declining prices from the 1952 level to a level of 225 per cent of 1910-1914 by 1958, remaining steady thereafter. The minimum time required for a soil conservation plan to provide a higher annual net farm income than extension of the present plan was 4 years under the assumption of steady prices and 5 years under the assumption of declining prices. The minimum time required for accumulated net farm income under a conservation plan to exceed accumulated net farm income under the present plan was 7 years when future incomes were not discounted and a longer period when they were discounted.

The additional capital required for each of 15 years after a conservation plan is adopted for a farm is not greatest at the time the plan is started but 5 to 8 years later. Increased capital needs vary from year to year after a plan is started and most are due to a greater investment in livestock. Indirect costs associated with a conservation plan, such as those for livestock, often exceed the direct costs of the conservation practices. The use of fertilizer when a conservation plan is begun helps to overcome

[1]Doctoral thesis no. 1541, submitted June 2, 1954. Chairman of Committee, Earl O. Heady, Department of Economics and Sociology.

[2]B.S.A., University of Toronto, Canada, 1949. M.S., Iowa State College, Ames, Iowa, 1950. Assistant Professor. Cooperator, Agricultural Experiment Station.

the drop in net farm income which ordinarily occurs. Credit should be made available not only for the conservation practices themselves but for related costs incurred. Credit is required in varying amounts for a number of years after a conservation is started. Loans for fertilizer, tiling, and other practices which are profitable but non-conservational would help to maintain farm incomes and increase the adoption of conservation practices.

Overall farm planning for conservation is necessary if practices which control erosion are to gain general acceptance. Education must play an important role. Farmers must become convinced that conservation farming will not lessen their satisfaction. They must want to adopt the practices and contend with them over a period of years. Conservationists must recognize the ramifications of proposed conservation plans on the farm business as a whole. The land, human and capital resources are unique for each farm situation. They must be considered on an individual farm business basis as they function simultaneously.

RELATIONSHIPS OF VALUES AND PROCESS CONCEPTS OF SELECTED STUDENTS TO GENERALIZATIONS IN NUTRITION[1]

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Limited research has been done to determine the motivating forces behind changes in food habits through education. The present study had its basis on the belief that the student could become interested in nutrition and could be motivated to maintain himself in an optimum state in relation to it. There was no evidence in the literature to indicate that values, goals, and process concepts of students had been used consciously and concurrently in nutrition education. The present study was made to discover whether process concepts of a selected group of seventh-grade students changed as they learned and applied principles and facts. In this manner nutrition facts and principles were related to goals and values of students. It was believed that consideration of process concepts and values in relation to valid factual generalizations comprises a basis of an effective nutrition education program.

Approximately 292 different statements of generalizations which were evaluated by a jury of nutritionists at Iowa State College, a specialist in scientific writing, and two junior high school teachers were approved and retained in a compilation of Generalizations for Teachers of Students Who Have Had No Chemistry.

The statements were classified according to the developmental tasks of late childhood and early adolescence. It was assumed that learning nutrition principles and facts related to these tasks would be strongly motivated if they were recognized as being instrumental in satisfying physiological, personal, and social needs.

One reason for ineffective teaching in the area of nutrition may be that teachers untrained in nutrition have difficulty in evaluating the conflicting information in the field and hence are insecure in the subject matter they present. This list of classified statements may serve as a reliable guide according to the present status of nutrition research. From this compilation teachers of students in the fifth through the thirteenth grades can select information most pertinent to the needs of their students. After the selection of the generalizations the information can be presented in a manner preferred by the individual teacher. In the same manner the statements may serve as source material for teachers of public-health nutrition, student nurses, and adult groups.

Although statements were kept simple, 32 terms were defined or explained because they were checked by two junior high school teachers as difficult to interpret to their students, or were considered by the investigator to need clarification.

Source materials used in compiling and validating nutrition information were listed in an alphabetical bibliography of authors for the convenience of teachers who might

[1]Doctoral thesis no. 1451, submitted July 22, 1953. Chairmen of Committee, Mattie Pattison, Department of Vocational Education, and Ercel S. Eppright, Department of Foods and Nutrition.

[2]B.S., University of Oklahoma, Norman, Okla., 1933. M.H.Ec.Ed., Ibid., 1939. M.S., Iowa State College, Ames, Iowa, 1948. Instructor.

wish to read background information with which to broaden their understanding of the generalizations.

Criteria for the statement of facts and principles in the form of generalizations were suggested.

Seventh-grade students at Story City, Iowa, and freshmen women at Iowa State College, Ames, Iowa, composed two classes in nutrition taught by the investigator in order to ascertain the ability of students to state generalizations. Thus it was possible to make a comparison of the statements which were obtained at the two grade levels. One student-stated generalization from each classification in three areas of subject matter, randomly sampled from the material taught during the seventh- and thirteenth-grade classes in nutrition, was classified and analyzed in the present study. Neither the number of students nor the subject matter used in the teaching were the same for the two age groups. However, the generalizations stated by the students were classified by a common method.

Findings reported in the present study were based on a small population which composed the samples studied and apply only to these small groups.

More than half of the generalizations stated by both seventh- and thirteenth-grade students were accurate. The seventh-grade students usually gave statements which contained one idea stated in simple words. They almost always made statements which could be applied to their areas of interest. The thirteenth-grade students often included facts and principles of interest per se, not necessarily applicable to the solution of their immediate problems. The advantage of relating generalizations to developmental tasks was evident when students in both classes displayed a keen interest in the subject matter presented and wished to discuss their personal problems as related to the generalizations they were asked to write. The older students displayed this tendency more than the younger ones. Badly confused ideas among the statements were few in number. Confused wording was more evident than confused ideas. Criteria for presenting generalizations to students were suggested.

A variety of methods was used to teach generalizations. Learning was facilitated when principles and generalizations were accompanied by moving pictures, animal-feeding experiments, demonstrations in which actual foods were used, graphs of the student's own growth, individual dietary records and other classroom activities which brought the principles into the realm of the student's experience.

Value patterns for girls, for boys and for the entire grades five, seven, nine, and thirteen were compared to discover differences that might be used as guides in planning curriculum content. Values studied for the fifth-grade students were not identical with those studied for the other three groups, but when possible the values of the four age groups were compared. The test of Hawkes was given to two sections of the fifth grade which included 14 girls and 21 boys. The test of Di Vesta was used in the seventh grade which included 14 girls and nine boys. The same test was given to 13 girls and 11 boys in the ninth grade. Forty freshmen men and 40 freshmen women were given the test of Di Vesta also.

Values for the seventh- and thirteenth-grade students were determined in two ways, the values of tests and the process concepts. Values tests were given to obtain background for teaching the nutrition unit. Process concepts were obtained in response to interview questions related to nutrition and the values they seemed to imply were assigned to discover the goals and values related to nutrition. The values obtained by the two methods are not comparable because of the lack of refinement of the interview technique. Further development of this procedure is recommended.

When values were analyzed for each grade as a whole, it was noted that in all four grades distinctive differences existed between the values of boys and girls. These differences should be recognized in motivation in nutrition education. The differences in the values for each grade as a whole were also distinctive and could serve as one basis for selection of subject matter to be presented as well as the method to be used in presenting it.

Process concepts of students were determined by use of two sets of interview questions related to facts and principles in nutrition which were designed for use with seventh- and thirteenth-grade students. Interviews were recorded on wire and were transcribed in type for classification and analysis of process concepts obtained in the responses to the questions.

An interview technique was developed which involved the use of 62 questions related to nutrition facts and principles for seventh-grade students and 67 questions for thirteenth-grade students. Of these questions approximately 43 yielded process concepts

of students which were related to nutrition. The other questions were used to lead up to the more difficult ones which required independent thinking. Goals and values implied by the process concepts were assigned by the investigator and were ranked according to the mean number of process concepts related to each value and goal.

The kind of questions used in the interview appears to be the basic factor in the worth of the process concepts obtained. Criteria for formulation of interview questions in nutrition, included in the present study, are based on experience obtained in this exploratory research.

Concepts obtained by interviews were classified under five headings: physical characteristics; food preferences and practices; relations with peers; relations with adults; and performance in work and play. After the process concepts were classified, goals and values which the investigator judged the concepts to imply were assigned to them. There were 14 values and three goals which seemed to be implied in the responses to the interview questions.

Many process concepts of seventh- and thirteenth-grade students were very similar as determined to responses to questions related to physical characteristics, food preferences and practices and performance in work and play, but they varied considerably in responses to questions related to peers and in relations with adults. The thirteenth-grade students gave a much freer response than the younger students to the interview questions in all the classifications.

The large number of responses to interview questions which seemed to imply the goal, health, indicated that it was prominent in the list of goals and values related to nutrition. A comparison of process concepts of seventh- and thirteenth-grade students related to health is included in the present study.

PANTOTHENIC ACID REQUIREMENT OF WEANLING PIGS ON A PURIFIED RATION[1]

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Department of Animal Husbandry

Forty-eight Duroc x Poland China x Landrace crossbred pigs were allotted according to outcome groups to 12 different ration treatments to study the pantothenic acid requirement of weanling pigs. A purified ration composed of starch, cerelose, Drackett protein, woodflock, corn oil, minerals, vitamins, and DL-methionine with levels of 2, 3, 4, 5, 6, and 7 mg. of pantothenic acid with and without chlortetracycline was fed. The average initial weight of the pigs was 25 pounds and they were fed to a final weight of approximately 100 pounds. The pigs were confined to wire floored individual crates for the entire feeding period.

A 48 hour collection of urine was made from each pig immediately prior to placing the pigs on the experimental ration treatments and again when each pig weighed approximately 75 pounds. The volume of urine from each pig was measured and an aliquot was stored for a pantothenic acid assay. Blood samples were drawn when the pigs weighed 75 pounds and hemoglobin, red and white blood cell counts, differential white cell counts, hematocrit and clotting time were all determined. Fecal samples were collected on two days and microbiological plate counts were made.

There were not significant differences in the rate of gain, daily feed consumed, or feed required for a pound of gain between the pigs being fed the different ration treatments. Neither were there any significant differences in hemoglobin, red blood cell count, white blood cell count, differential white blood cell count, hematocrit, or clotting time between the pigs on the 12 ration treatments. The amount of calcium pantothenate excreted when the pigs weighed 75 pounds was found to be closely related to the level of pantothenic acid the pigs were receiving in their ration.

There were fewer lactobacilli, molds, yeast, fungi, and anaerobes and the total count was less in the feces from pigs fed the antibiotics. However, the coliforms and the streptococci organisms were in larger numbers in the feces of antibiotic fed pigs. Molds, yeasts, fungi, streptococci, and coliforms were fewer in numbers in fecal samples produced by pigs fed 7 mg. of pantothenic acid than in samples from pigs fed

[1]Doctoral thesis no. 1533, submitted May 23, 1954. Chairman of Committee, Damon Catron, Department of Animal Husbandry.

[2]B.S., Purdue University, Lafayette, Ind., 1945. M.S., Iowa State College, Ames, 1948.

lower levels of the vitamin. However, these differences in numbers of microorganisms in the feces apparently had little or no influence upon the performance of the pigs since these differences cannot be correlated with any differences in gain, feed efficiency or deficiency symptoms.

No apparent deficiency symptoms developed in any of the pigs during the course of the experiment. The pigs fed the 2 and 3 mg. levels of pantothenic acid with chlortetracycline did develop rougher hair coats than did the pigs on the same levels of pantothenic acid without the antibiotic. A post mortem examination of one pig fed the 2 mg. level of pantothenic acid was made. No internal symptoms of a pantothenic acid deficiency was found.

Considering the renal excretion levels of calcium pantothenate, growth rate, feed efficiency and the failure to detect any of the deficiency symptoms of a pantothenic acid deficiency, 2 to 4 mg. of pantothenic acid per pound of feed appeared to be adequate for normal growth of pigs under the conditions of this experiment.

HISTOLOGY OF THE MAIZE PLANT IN RELATION TO CORN BORER INFESTATION[1]

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This study was undertaken to study some anatomical features of the corn plant in relation to invasion by the corn borer. The inbred lines and hybrids used in the study represent extremes of resistance and susceptibility.

Corn borer larvae do not survive on very small plants. Larvae began to survive on the ninth day after emergence of the plant from the soil in 1952, and on the eighth day in 1953. At this time plants of susceptible line WF-9 had six emerged leaves and an average height of 26 cm. The resistant line L-317 had four or five emerged leaves and an average height of 16 cm. The survival of larvae continued to be high after this time.

After the ultimate number of leaves is initiated, the vegetative apex elongates and becomes a transition type apex. The earliest transition apices were found six days after the plants emerged from the soil. The first floral initiation was found on the eleventh day. Plants comparable to those found to be in transition were the first to become capable of supporting young corn borer larvae. When the plants were in the vegetative, leaf-producing phase, the larvae did not become established.

Tissue differentiation of leaves in the whorl was found to be least advanced below the moist area, and more advanced distally. Leaves of susceptible lines WF-9 and M-14 differentiate at a lower level than the resistant lines L-317 and W-22.

Larvae are found to feed almost entirely from the upper surface of the leaves in the moist area, and the bulliform cells were found to be the locus of attack. The dissimilar staining reactions of the walls of the bulliform cells of resistant and susceptible lines indicate undetermined chemical differences. Total outer cell wall thickness of the fundamental type epidermal cells was greater than of the bulliform cells. Lines M-14 and WF-9 have a wider bulliform group than L-317 or W-22.

Resistant lines have pin-hole lesions involving relatively few cells. The susceptible lines have larger lesions, in proportion to the degree of susceptibility and the size of the larvae. The position and shape of bulliform cell groups regulate the shape of the lesions.

Larvae enter the midribs of the moist area from the upper side and feed in the parenchyma of the mature midrib. Hypodermal strands of sclerenchyma offer resistance to the borer invasion at the edges of the midrib. Continuous hypodermal sclerenchyma is found in the midregion of the rib. Resistant midribs have sclerenchyma strands close together and have less parenchyma than susceptible midribs.

Plugging of the vascular tissues by microorganisms in the region of attack was noted. Cell proliferation was also found in the region of attack.

[1]Doctoral thesis no. 1545, submitted June 3, 1954. Chairman of Committee, John E. Sass, Department of Botany and Plant Pathology.

[2]B.S., Parsons College, Fairfield, Iowa, 1950. M.S., Iowa State College, Ames, Iowa, 1952. Graduate Assistant, Agricultural Experiment Station.

Resistance in the collar was found to be associated with the close spacing of major bundles and of the sclerenchyma sheath, and with the total thickness of the collar. The larvae feed upon the parenchyma between the vascular elements.

Resistance in the leaf sheath is associated with the distance between sclerenchyma strands on the adaxial side, and with total thickness of the sheath in the feeding area. The larvae feed upon the parenchyma between and under the sclerenchyma strands. The larvae may enter the parenchyma in the thick midregion, and some surface feeding may occur in the margins where the parenchyma is not thick enough to allow entry.

DIFFERENTIAL CHARACTERISTICS RELATED TO LATER OCCUPATION OF GRADUATES FROM THE DIVISION OF AGRICULTURE AT IOWA STATE COLLEGE[1]

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The purpose of this study was twofold. Graduates of the Iowa State College Division of Agriculture were studied (1) to determine characteristics related to success in later occupation as measured by earned income, and (2) to determine characteristics related to occupational choice of agricultural college graduates.

The study was limited to 500 graduates of the Iowa State College Division of Agriculture during the period 1932 to 1952, inclusive. One hundred graduates in each of the occupational areas of sales, journalism, extension, farming, and college teaching and research were included. Names of graduates and such information as their occupations, earned income, and certain other characteristics were obtained from questionnaires returned in 1952 by these same graduates for another study. Additional information concerning the graduates was obtained from college records. From these sources, information was secured regarding characteristics believed to bear some relationship to either occupational success or occupational choice. The characteristics were (1) college grade average, (2) agriculture grade differential, (3) science grade differential, (4) social science grade differential, (5) communications grade differential, (6) high school average, (7) scholastic aptitude, (8) extracurricular activities, (9) height,and (10) farm or non-farm residence before college matriculation. Grade differential was the designation given to the difference between the average grade in one subject matter area and the average in three other areas.

The use of earned income as a criterion of occupational success was based on availability of that information and the lack of other criteria of success. A quadratic equation of the form $Y = -aX^2 + 60aX + C$ was obtained by the method of least squares and solved for earned income and number of years since graduation for each occupation. Solution of the equation provided an adjusted median income for from one to twenty-one years after graduation which was used to separate graduates within the occupations into "above average" and "below average" earned income groups. Although it was not an express purpose of this study to compare earned income of the various occupations, it was noted that solution of the quadratic equations yielded widely varying earned income values for graduates in the five occupations. Predicted maximum earned income 30 years after graduation varied from 5,577 dollars for graduates in extension to 9,374 dollars for graduates in journalism.

In the analysis of characteristics related to earned income, the technique of biserial correlation was used to determine the relationship of each of the characteristics chosen to high-low earned income. The t-test was used to test for significance of the difference between high and low earned income groups in each occupation for each of the characteristics. The only characteristics which were revealed to have a significant relationship to earned income were college grade average and communications grade differential. For graduates engaged in college teaching and research, those with higher college grade average had a tendency to be in the higher earned income group with an r_{bis} of 0.2433 and a t-value of 1.974 which was significant at the five per cent level. A negative correlation of -0.2867 and a t-value of 2.3530 was found between communi-

[1]Doctoral thesis no. 1470, submitted November 13, 1953. Chairman of Committee, James E. Wert, Department of Vocational Education.

[2]B.S., Iowa State College, Ames, Iowa, 1947. M.S., Ibid., 1952.

cations grade differential and earned income for graduates engaged in extension work. The negative correlation indicated that those graduates who did less well in communications subjects have a tendency to have higher earned incomes than the graduates who do better in communications than in other subjects. None of the other characteristics was significantly different between high and low earned income groups in the five occupations considered.

Chi square was used to determine the significance of differences between high and low earned income groups with regard to farm or non-farm residence prior to college matriculation. All chi square values were nonsignificant, indicating that no differences could be shown between high and low earned income groups with regard to farm or non-farm residence prior to college.

Multiple classification analysis of variance was used as a more sensitive test of significance, whereby variations among the occupations could be controlled. No significant differences between high and low income groups could be demonstrated when occupational classification was controlled. Highly significant differences among occupations without regard to earned income groups were obtained for the characteristics (1) college grade average, (2) agriculture grade differential, (3) science grade differenyial, (4) communications grade differential, (5) high school average, (6) scholastic aptitude, and (7) extracurricular activities. Hence, the usefulness of the characteristics appeared to lie in the realm of occupational choice rather than in distinguishing between higher income and lower income graduates.

Discriminant analysis provided a technique for evaluating the similarity of an individual to graduates established in the five occupations considered in this study. Six characteristics for use in the discriminant equations were selected on the basis of significance of F-values for analysis of variance. The characteristics were (1) college grade average, (2) agriculture grade differential, (3) science grade differential, (4) communications grade differential, (5) scholastic aptitude, and (6) extracurricular activities.

The discriminant equations were used to compute multiple biserial correlations which showed the relationship between the six characteristics and tendency for graduates to be in one occupation rather than another. Magnitude of the correlations, varying from 0.1289 to 0.7166, indicated that the characteristics chosen provide a reasonable basis for discriminating such occupations as college teaching and journalism from any of the other occupations studied. The same characteristics were found to be of less value, however, for discriminating the occupations of sales, farming, and extension.

To provide a scoring key by which similarity of characteristics of an indicidual to occupational pattern could be obtained, equations were solved to discriminate each occupation from the other four studied. The equation for any one occupational pattern was obatined by averaging the coefficients which were found for that pattern as contrasted to each of the other four. A series of tables were prepared from which a counselor could obtain scores for an individual, evaluating similarity to graduates already established in occupations. To obtain evidence concerning the usefulness of the scoring system, each of the 500 graduates included in the study were scored for similarity to occupational pattern. It was recognized that the degree of usefulness revealed by scoring the individuals with whom the system was devised would be an over-estimate of the value of the scoring system.

Similarity scores for the 500 graduates gave further indication that the equations discriminate the occupations of journalism and college teaching from sales, extension, and farming, as well as from each other. The system did not appear to be satisfactory, however, for discriminating sales, extension, and farming.

It was suggested that information concerning interests and personality traits of students could be assembled as college routine. That information, incorporated in discriminant equations with the characteristics used in this study, might provide a more accurate method of determining similarity of agricultural college graduates to occupational pattern.

SEQUENCES OF AMINO ACID RESIDUES IN INSULIN[1]

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The literature dealing with the chemical structure of insulin has been reviewed. By means of fragmentation of the molecule, Sanger has proposed a sequence purported to account for all amino acid residues present in the protein (1, 2). There are, in the literature, reports which support and some which contradict his findings.

The purpose of the present investigation was to examine the insulin structure by an independent method. A quantitative amino acid residue sequence procedure which could be applied without prior fragmentation of the protein (3) was employed. In order to obtain information about the terminal amino acids, electrophoretically pure crystalline bovine insulin was treated first with phenylisothiocyanate and then with 6 N hydrochloric acid. To investigate positions other than terminal, the 6 N hydrochloric acid hydrolysis was replaced by treatment with dry dioxane saturated with hydrochloric acid gas. Microbiological assay of the amino acids before and after the treatments revealed decrements in the amount of those acids that had reacted with phenylisothiocyanate. The following data, most of which are in agreement with Sanger, were collected.

In an insulin sample of molecular weight 12,000, there are six phenylalanine residues, two of these having free amino groups. Valine and two or three isoleucine residues occupy second positions; two isoleucine and two valine residues were found in this position by Sanger. In third positions are aspartic acid and two valine residues, and an undetermined number of glutamic acid residues occur as fourth amino acid from the aminoid terminus of the insulin peptide chains.

Contrary to the results of Sanger (2) and Fromageot (4) and in accord with those of Brand (5) and Tristram (6), three isoleucine residues per molecule of insulin were found in three determinations.

With a view toward developing a more direct sequence procedure, some of the properties of phenylthiohydantoins were investigated. The phenylthiohydantoins derived from eleven common amino acids were found to dissolve slowly in ether, the extracting solvent commonly employed, whereas they were found to be readily soluble in N,N-dimethylformamide and pyridine. When the phenylthiohydantoin of valine was added to buffered solutions of bovine serum albumin, it could be recovered quantitatively by ten ether extractions at pH 2.2, 4, 6, and 8 but not at pH 10. α-Napthylisocyanate reacted with valine and isoleucine more rapidly than phenylisothiocyanate, but the hydantoin produced on acid treatment was more insoluble in ether. Octadecylisocyanate reacted more slowly than phenylisothiocyanate. The estimation of phenylthiohydantoins by means of their conversion to amino acids is not entirely satisfactory since the conversion is only seventy-five per cent complete. However, the estimation of the hydantoins by means of the optical density of their solutions at 268 mμ is unaffected by pH and is satisfactory if other ultraviolet-absorbing materials are absent.

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[1]Doctoral thesis no. 1450, submitted July 17, 1953. Chairman of Committee, Sidney W. Fox, Department of Chemistry.

[2]B.S., Xavier University, Cincinnati, Ohio. 1949.
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CHIPPING QUALITY OF IOWA GROWN POTATOES[1]

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The chipping quality of 65 potato varieties and seedling selections was evaluated. Specific gravity of tubers, yield of chips, per cent oil absorption of chips, reducing sugar content of the raw potatoes and color rating of chips were studied. Correlation coefficients were computed for the following:

1. Specific gravity of tubers and yield of chips.
2. Specific gravity of tubers and per cent oil absorption of chips.
3. Specific gravity of tubers and reducing sugar content of the raw potato.
4. Specific gravity of tubers and color rating of chips.
5. Reducing sugar content of the raw potato and color rating of chips.

Regression coefficients were also computed for the above factor and regression lines presented graphically.

The correlation coefficient for specific gravity and chip yield was 0.847 and for specific gravity and oil absorption it was -0.614. These relationships are sufficiently rigid to permit the chip manufacturer to estimate yield of chips and oil absorption on the basis of the specific gravity of his raw potatoes.

Reducing sugar content and color rating of chips appeared to be largely inherent in the variety. Although the correlations of specific gravity with reducing sugar content and with color rating of chips were significant, the regressions were of little use in making estimates.

The highest correlations obtained were between color rating of chips and reducing sugar content of raw potatoes ($r = 0.747$, 0.883, and 0.877). When the sugar content of raw potatoes was below 0.05 per cent the color rating of chips was generally good with color values being below (lighter than) those expected on the basis of the regression. When the sugar content of the raw potatoes increased above 0.2 per cent the actual regression was more in evidence. Chips produced from potatoes with a reducing sugar content of 0.2 to 0.5 per cent were on the borderline of being acceptable for color.

Two years' results of the effect of foliar sprays of 2,4-D and maleic hydrazide upon the chipping quality of Kennebec, Pontiac, and Cobbler varieties are also presented. The effect of these chemicals upon the specific gravity of tubers, reducing sugar content and color of chips from these varieties was negligible.

The results of a 2,4-D experiment involving different formulations on the variety Sebago did indicate that foliar sprays on the vines resulted in lower reducing sugar content and improved color of chips after storage and conditioning the potatoes.

On the basis of these experiments it is suggested that the effect of both 2,4-D and maleic hydrazide may depend upon varietal response and possibly upon environmental conditions. Need for further study on varietal response to these chemicals is indicated.

[1]Doctoral thesis no. 1510, submitted March 10, 1954. Chairman of Committee, C. E. Peterson, Department of Horticulture.

[2]B.S., Iowa State College, Ames, Iowa, 1950. Cooperator, Agricultural Experiment Station.

ROOSTING OF BRONZED GRACKLES AND AVIAN ASSOCIATES AT AMES, IOWA[1]

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The roosting of bronzed grackles and avian associates, the starlings, cowbirds, and robins, and their evening flights to the roost in residential areas in Ames, Iowa, were kept under observation from August, 1949, through November, 1952. Objectives of the study were as follows: (a) to learn whether or not certain readily measurable features of the roosting sites were correlated with the extent to which they were used by the birds; (b) to learn whether or not readily measurable weather phenomena were correlated with the behavior of the birds; (c) to observe the responses of the birds to interference by people; and (d) to add to our knowledge of the natural history of the bronzed grackles and their associates.

Roosting began in Ames during June and ended in November. It was primarily noted in the relatively abundant American elms and hard maples, but it also occurred in rather high percentage among green ashes, box-elders, cottonwoods, hackberries, and silver maples, all of which were present in small numbers. Roosting early in June soon spread from hard maples to other deciduous trees, and thereafter there was no evidence of any consistent seasonal change in the use of species of trees.

In general, the percentage of trees used as roost places varied directly with the diameters of trunks at breast height. With only four exceptions, trees less than seven inches in trunk diameter were not used by the birds, and the lowest value observed was four inches.

Except for the American elms which showed no consistent trend, the degree of use given the trees (light, moderate, or heavy) varied directly with the mean diameter of the trunk at breast height. The mean diameters of hard maple roost trees were considerably less than those of other tree species.

Both on numerical and on percentage bases the birds used far more street trees than back yard trees. A decided tendency of the birds to roost in closely grouped trees may have been the reason, for there were few close groupings of roost-size trees in back yards.

In general, the degree of use given the trees varied with the amount of cover provided by the crowns, but variations in the extremely dense hard maples did not result in differential use by the birds. The rather open crowns of many species of trees may have been a major reason why more of them did not serve as roost places.

Most efforts at roost control in Ames by individual citizens were of a desultory nature. Noise-making and beams of light apparently were at least partly responsible for several shifts in roost sites. Firecrackers thrown among the roosting birds cleared one extensive roost site, and the use of one shotgun for three nights moved 20,000 birds at another. Supersonic frequencies had no noticeable effect.

Four major flights entered Ames each evening, with the birds present in approximately the following percentages: grackles, 74; starlings, 22; cowbirds, 3; and robins, 1. Grackles and robins usually flew at tree-top height, starlings at two or more times grackle altitude, and cowbirds flew slightly abote the grackles. Mixed flocks flew at the level of the most abundant species, though none were ever seen at the higher altitudes used by the starlings. As the season advanced the flight lines broadened until three of them were seven or more blocks wide, but the birds were not uniformly distributed throughout. The broadening was correlated with the growth of the roost and with shifts to new sites therein. Although total numbers of birds in the flights were low in June, they increased until August or September, accompanied by a growth of the size of the flocks. An estimated peak of over 69,000 birds, which roosted on a total of 120 city blocks during the season, was reached in 1950. Progressive decreases followed during the next two years.

Grackles were the first birds to begin the daily flights to the roost, starlings second, and cowbirds were third. For flight peaks and endings the order was reversed: cowbirds, starlings, grackles. Robins were always the last to enter the roost. As the season advanced the beginnings and peaks of the flights of grackles, starlings, and

[1]Doctoral thesis no. 1431, submitted July 8, 1953. Chairman of Committee, George O. Hendrickson, Department of Zoology and Entomology.

[2]B.A., Iowa State Teachers College, Cedar Falls, Iowa, 1935. M.A., Columbia University, New York, N.Y., 1936. Instructor.

cowbirds tended to occur closer to sunset time. The same was true for flight endings for grackles, but starlings and cowbirds showed little seasonal change therein. As the season advanced the total duration of the flights decreased.

Effects of various weather elements and time of year on the daily variations in flight peak time for grackles and starlings of two flights were tested by the method of multiple linear regression. Results of the analysis showed the following: grackles of one flight were affected primarily by wind velocity, cloudiness, and season; grackles from the other flight responded chiefly to zenith light, cloudiness, and wind velocity; starlings from both flights were influenced chiefly by season, zenith light, and cloudiness. Regression coefficients for season were negative, and those for the other factors were positive. The higher light values obtained when skies were moderately cloudy than when clear caused the regression coefffcient for zenith light to have a positive value rather than a negative one.

Thunderstorms caused locally gathered birds to rush to the roost when a storm struck, but had no effect on birds that were some distance away. Light precipitation had no noticeable direct effect.

When populations of the same flight were compared on successive days, the total numbers of birds to come to the roost were less with tail winds of 500 or less feet per minute velocity than with comparable head winds. The effect of stronger head winds and tail winds on the populations of the same flight on successive days was not studied.

The birds frequently performed a maneuver which was called "dipping" in the thesis. It involved a sudden drop in altitude, flight at the new level for a distance, then a return to the original level. No stimulus was found to cause the behaviorism. It increased in frequency and intensity as the season progressed, though it was not seen every evening.

The birds never crossed moving trains or standing, noisy engines. Airplanes flying at moderate heights over the birds had no noticeable effect on them.

Suggested methods of control included selective cutting of trees to eliminate close groupings, and the use of the shotgun on the incoming flights early in the season.

SEPARATION OF INDIVIDUAL RARE EARTHS BY LIQUID-LIQUID EXTRACTION FROM MULTICOMPONENT MONAZITE RARE EARTH NITRATES[1]

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A liquid-liquid extraction process was developed for the separation of the light rare earths. The research consisted of experimental determination of equilibrium data, development of a method for correlating important process variables, countercurrent liquid-liquid extraction on a small scale, design and testing of a pilot plant mixer-settler unit, and proving that the rare earths can be separated inexpensively by liquid-liquid extraction.

Unique equilibrium conditions were found for the rare earth nitrates-tributyl phosphate-water systems. The equilibrium curves for individual pure light rare earths practically coincide. The equilibrium curves for light rare earth mixtures coincide with the equilibrium curves for the pure rare earths. Nitric acid decreases the solubility of rare earths in the organic phase. The separation factors increase with increasing rare earth concentration. The separation factors are almost independent of the composition of the rare earth mixture.

It is advantageous to operate a rare earth extractor at high rare earth concentrations where the separation factors are the highest, since the separation factors decrease markedly with decreasing rare earth concentration.

A calculation method was developed that takes advantage of the unique equilibrium relations and permits the operation of any number of stages at high rare earth concentrations where the separation factors are the highest. The calculation method correlates

[1]Doctoral thesis no. 1501, submitted January 11, 1954. Chairman of Committee, Morton Smutz, Department of Chemical Engineering.

[2]B.Ch.E., University of Detroit, Detroit, Michigan, 1950. Research Assistant, Institute for Atomic Research.

all the important process variables encountered in the rare earth extraction system. The concept of the reflux ratio, frequently employed in other separation processes, was employed as a parameter for the following variables: number of theoretical stages; flow rates of the three liquid streams entering the extraction system; and the concentration of the solutes in the incoming feed stream. The calculation method was tested with a simulated extraction unit and a pilot plant mixer-settler unit and was found to be valid. The performance of the mixer-settler unit was predicted with considerable accuracy.

A simple pilot plant mixer-settler was designed to handle liquids of high density and viscosity. The interface level in each settler was controlled independently of all other stages by means of a simple adjustment. This mixer-settler was employed in pilot plant studies with monazite rare earth nitrates.

Significant separations of the rare earths were made on a pilot plant scale. A binary cerium-lanthanum mixture containing about 0.6 per cent heavier rare earths was prepared from a monazite rare earth mixture in a 14-stage extractor. A binary praseodymium-neodymium mixture containing less than 0.05 per cent samarium and gadolinium was prepared from a feed mixture containing 15 per cent praseodymium, 75 per cent neodymium, 6 per cent samarium and 4 per cent gadolinium. The above binary praseodymium-neodymium mixture was used as feed for preparing a neodymium fraction containing 1 per cent praseodymium and 6 per cent heavier rare earths. The pilot plant run in this last step did not reach steady state due to a lack of enough feed material.

A preliminary cost estimate was made of a liquid-liquid extraction process to purify rare earths from monazite rare earth nitrates. The estimated conversion cost for 99 per cent lanthanum and 99 per cent cerium was about 7 cents per pound when based on a production rate of 16,000 pounds of monazite rare earth nitrates per day.

CHANGES IN KNOWLEDGE AND OPINION OF BUSINESS AND PROFESSIONAL PEOPLE ABOUT COOPERATIVE ASSOCIATIONS[1]

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This is an exploratory study of differences in knowledge and opinions of business and professional persons about agricultural cooperative associations before and after a public relations campaign designed to influence their knowledge and opinions. The campaign was conducted during 1950-1951 using printed materials only. The Joint Committee of Cooperatives in Iowa Falls, Iowa, sponsored a series of 13 advertisements in the Iowa Falls Citizen and published a pamphlet which they distributed to the business people and part of the professional people in Iowa Falls. Also, the Iowa Associated Businessmen Inc. of Ames, Iowa, sponsored a series of eight advertisements opposing cooperatives which were printed in the same newspaper.

The research project was conducted under the auspices of the Iowa State Agricultural Experiment Station.

The purposes of this study were:

1. To determine if changes in knowledge and opinions took place during the period when the public relations campaign was being carried on.
2. To determine personal and social factors related to seeing and reading of printed materials used in the public relations campaign.
3. To determine personal and social factors related to differences in knowledge and opinions of agricultural cooperatives.

The population studied was the business managers and professional people in Iowa Falls and similar communities in the Midwest. Similar samples from this population living in Iowa Falls were interviewed, one before and the other after the public relations campaign.

Scores were devised to measure levels of knowledge and favorableness of opinions.

[1]Doctoral thesis no. 1559, submitted June 7, 1954. Chairman of Committee, Ray E. Wakeley, Department of Economics and Sociology.

[2]B.S., Iowa State College, Ames, Iowa, 1947. M.S., Ibid., 1948. Assistant Professor. Cooperator, Agricultural Experiment Station.

No significant differences were found between the before and the after samples in level of knowledge about the structure and operation of cooperatives and the level of knowledge about the tax responsibilities of cooperatives. No significant difference was found between the two samples in the favorableness of opinion toward cooperatives.

Favorableness of opinion was the only factor significantly related to seeing and reading of the printed materials. A greater proportion of those who were less favorable toward cooperatives had read the advertisements in the local newspaper.

Ministers and school teachers had more favorable opinions toward cooperatives than others. Those people with more than 12 years of formal education had more favorable opinions toward cooperatives. Those who had discussed cooperatives with others had less favorable opinions.

Each of the personal and social factors tested was related to knowledge about the structure and operation of cooperatives. A greater proportion of those who had more knowledge about the structure and operation of cooperatives had more than 12 years of formal education, had farm backgrounds, were engaged in professions, were 39 years of age or younger, had discussed cooperatives with others and had more favorable opinion toward cooperatives.

Age, education, and occupation were not related to knowledge of the tax responsibilities of cooperatives. Those with farm background knew more about tax responsibilities of cooperatives. Those who had discussed cooperatives with others had less knowledge of the tax responsibilities of cooperatives.

Knowledge about cooperatives was limited among the people represented in this study.

PRODUCTION PLANNING OF CROPS FOR IOWA FARMS – USING ACTIVITY ANALYSIS AND LINEAR PROGRAMMING[1]

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The main objective of this study has been the determination of the crop production program which maximizes total revenue for different soil areas in Iowa and for different levels of resource ownership. The analysis was carried out by the use of the simplex method of the linear programming technique. Accordingly, an optimum (revenue maximizing) crop program was determined for fourteen main soil associations. Six resource quantities were considered for each and the analysis was repeated for a second price period. In all, 168 situations were considered. Only one production technique or process was used in the analysis. That is, only one combination of resource inputs per unit of product was considered for each crop and each area. The analytical method lends itself well to considering several production techniques. However, the lack of yield data which reflect the results of different techniques accurately made this extension inadvisable.

The analysis has substantiated the hypothesis that the optimum plan will differ from farm to farm, even on the same soil type, if the quantity of resources available for production is different. This optimum plan will vary between areas due to relative differences in crop yields. Changes in price ratios over time may cause the optimum production plan of one period to be relatively less favorable in another price period. Therefore, no one combination of crops can be considered optimum for all farms, nor is the program which was optimum at one time necessarily optimum at some time in the future.

The results obtained in Logan Township demonstrate the findings of the study. Corn and flax were the most profitable combination of crops for part of the land (1948–1952 average price levels were used) and part of the acreage was not planted, when capital was severely limitational. As the quantity of available capital was increased, part of the unused acreage and part of the flax acreage were planted to corn. With unlimited capital the most remunerative use of resources was found to be in the production of

[1]Doctoral thesis no. 1546, submitted June 3, 1954. Chairman of Committee, Earl O. Heady, Department of Economics and Sociology.

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corn exclusively. The average price of oats and soybeans during 1941-1944 was more favorable, relative to the price of corn, than during 1948–1952. Using 1941–1944 price ratios, soybeans were included in the optimum plan in Washington Township. However, their inclusion was associated with low available capital. As the capital quantity was increased soybeans were replaced by corn, in spite of the relatively favorable price of the former crop in 1941–1944. Labor tended to be limitational in Logan Township although the restriction imposed in this township was less severe than in areas where a large dairy enterprise was typical.

The selection of the program which results in maximum revenue may not be the farmer's only concern. It is, however, of very real importance in the decision making process, if for nothing more than permitting the farmer to know the opportunity cost of choosing some other objective.

Most farmers probably do a type of budgeting to arrive at an optimum program given their individual objectives. They take stock of their resource supply and then determine the levels at which the several crop enterprises may be carried on. The method is laborious since a very large number of crop combinations or programs exist for even a relatively small farm enterprise. The possibility also exists that the optimum plan will never be considered, since there is nothing in the budgeting technique which provides for all alternatives being considered.

Linear programming is an alternative to the budgeting technique in individual farm analysis. The method is exact. It cannot fail to lead the investigator to the optimum plan; that is, all possibilities will be considered. Several internal checking methods are available which cause arithmetic errors to be obvious. The determination of the optimum plan can be carried out quickly with linear programming.

The development of linear programming and its application to agricultural economics greatly enhance the opportunity of carrying on individual farm planning. While the resource situations which have been included in this analysis are considered to be applicable to many Iowa farms, individual farm analysis might result in the recommended program being somewhat different in many instances. Unlike many of the research tools which have been available to agricultural economists, linear programming lends itself well to individual farm analysis. Budgeting has been the main exception. Either analytical method requires that the research worker be able to specify resource quantities, production opportunities which are approximately equally profitable, production techniques and the quantity of product which may result from each. Price expectations must also be formulated before the relative emphasis which should be given each opportunity in a revenue maximizing program can be determined. None of these requirements is unrealistic. Resource quantities, prices and techniques change over time, however, and new opportunities become available. Therefore, the necessity for program revision is apparent. Because of the relative ease with which the optimum program may be determined linear programming is a considerable improvement over budgeting.

A NEW APPROACH TO DIRECT-READING SPECTROCHEMICAL ANALYSIS[1]

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The use of spectrochemistry as a means of industrial process control has increased sharply in recent years. In many cases spectroscopy has largely replaced chemical techniques for routine analytical work. Photographic spectroscopy for quantitative work has given way to the direct intensity measuring instruments in cases where very rapid, accurate analyses must be performed.

Modern direct intensity measuring equipment, in which spectral intensities are measured by multiplier phototubes, have several drawbacks. The most important of these include the use of separate exit-slit, phototube assemblies for each spectral line

[1]Doctoral thesis no. 1475, submitted December 5, 1953. Chairman of Committee, V. E. Fassel, Department of Chemistry.

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whose intensity is of interest. Since multiplier phototubes vary in their characteristics from tube to tube and from time to time, frequent calibration runs must be made to preserve analytical accuracy.

In the research which lead to this thesis a new method of direct spectral intensity measuring was investigated. In the instrument using this technique a single multiplier phototube was used to measure the intensities of all spectral lines of interest. An arrangement was used whereby the spectrum from a converted Jarrell-Ash 1.5 meter Wadsworth mounting spectrograph was scanned rapidly and repeatedly past a single exit-slit, phototube assembly. An alternating-current system was used throughout so that dark current from the phototube did not interfere with the spectral intensity measurements.

An oscillograph was synchronized with the spectrum scan, and the output of the phototube was fed to the vertical amplifier so that the spectrum could be visually monitored at all times. Synchronization of the oscillograph (and associated equipment) was accomplished by a slotted disk mounted on the spectrum scanning mechanism. Light from a small bulb passed through the slot to a germanium phototube (Sylvania IN77). The resulting pulse was sharpened and fed to the external synchronization input of the oscillograph.

The spectral intensities were measured by placing a grid of 50 opaque lines on the face of a cathode-ray tube with P-5 phosphor. Vertical deflection voltages were obtained from the monitor oscillograph, and no horizontal deflection was provided. A multiplier phototube in a light tight box was mounted over the screen of the cathode-ray tube. Thus, as the electron beam was deflected, the "spot" alternately was covered and uncovered by the grid lines producing a pulse wave-form in the phototube output such that the number of pulses was proportional to the degree of deflection. As the electron beam moved in response to the signal from the spectrum-detecting phototube, "bursts" of pulses were produced which contained pulses of a number proportional to the intensity of the spectrum lines.

In order to separate the pulse bursts corresponding to the spectral lines of interest from the general spectrum, synchronized gates were used. The same pulse which triggered the sweep oscillator of the monitor oscillograph triggered delay univibrators whose delay period was adjustable. A separate delay univibrator was provided for each spectral line which was measured. The delay univibrator in turn supplied a trigger pulse which tripped a gate univibrator, again one for each spectral line of interest. The gate univibrators supplied a square wave which activated gating amplifiers. Only at the time that the gating pulse was applied to the gating amplifiers would a signal be passed. When the general pulse burst spectrum was applied to the gating amplifiers, those spectral lines of interest were separated.

The time that the gating pulse was applied to the gating amplifiers was determined by resistance-capacitance values in the gating univibrator circuit. A stepped selector switch allowed adjustment of the gating period over a range of values. The instant that the gating pulse occurred was observed visually by injecting a portion of the gating signal onto the control grid of the cathode-ray tube in the monitor oscillograph. Thus, when the gating pulse occurred, the trace was brightened. In order to set the gates to coincide in time with spectral lines whose intensities were to be measured, the delay univibrators were adjusted until the bright portion of the trace just covered the spectral lines as viewed on the monitor oscillograph.

The pulse bursts, containing the spectral line intensity information, were evaluated after gating by high speed scalers. By noting the number of counts on the scaler registers, the total, time-integrated intensities of the spectral lines were determined.

In spectrochemical analysis it is necessary to determine ratios of integrated intensities rather than absolute intensities. Therefore, a computing unit was built which would accumulate the integrals of the intensities on multiturn potentiometers. After the exposure period the computer measured the ratios of resistances (equivalent to determining ratios of integrated intensities) and recorded these ratios on a special strip chart recorder. In practice, a series of standards, containing various known amounts of impurity in a matrix, was run, and the deflections on the recorder were correlated with the percent composition.

The direct intensity measuring instrument exhibited a precision of analysis of ± 1 per cent. In all cases the errors contributed by the instrument were smaller than errors which were due to difficulty in controlling source variations. Operation with continuous discharge sources, such as flames and the D.C. arc, was satisfactory, but it was not possible to make intensity measurements of spectra excited in either high-

frequency or synchronized spark discharges with the instrument in its present form. This is rather unfortunate because these sources show much better analytical precision than the D.C. arc.

It was shown, however, that spectral lines scanned past a single multiplier phototube, exit-slit assembly, could be isolated and their intensities evaluated and integrated with good precision. It is hoped that further experimentation will make it possible to use controlled spark discharge of a type which is arc-like in character so that the high inherent precision of the direct-reader can be realized.

A COMPARISON OF CYTOPLASMIC-GENOTYPIC INTERACTIONS IN A GROUP OF CYTOPLASMIC MALE STERILE CORN TYPES[1]

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Decided interest has arisen in the application of cytoplasmic male-sterility to the commercial production of hybrid seed corn. Utilization of this genetic contribution would presumably allow discontinuance of the detasseling procedure, a somewhat costly and laborious operation entailed in the production of hybrid seed corn under conventional methods.

Any type of cytoplasmic male-sterility, in order to be suitable for use as a commercial production program, must remain stable in expression of sterility under a wide range of environmental conditions. The mode of inheritance must be simple enough to facilitate transfer to other lines, and effective fertility restorer genes must be available. The male-sterile character cannot have any adverse effect on yield or other agronomic characters.

In this investigation a total of eight cytoplasmic male-sterile corn types, each from a different source, was collected for purposes of comparison and evaluation. An indirect method, that of crossing each to a series of tester lines serving as fertility differentials, had to be adopted to test differences between types of male-sterility. Within the limits of test crosses made, the U.S.D.A., Brazilian, Vg, and Reid sources were not greatly different in the cytoplasmic-genotypic interactions involved. The Vg and Reid types originated from the Iowa Agricultural Experiment Station breeding and genetic material. The Texas form of male-sterility was distinctly different from each of the other seven sources, as was also the Kys type. Two male-sterile single crosses were included in the collection tested, M1984 x M14 and J.C.33-16 x Mo2RF. Although difficult to compare with the others, the tests made indicate that the two types differ from each other, and are unlike any of the other sources observed.

In order to compare the various sources of cytoplasmic male-sterility in degree of environmental influence, each type was planted at three different dates, approximately two weeks apart. Single crosses involving each of the eight sources with the series of fertility differential tester lines were included in the date of planting experiment. The single cross M1984 x M14 was the only one of the original cytoplasmic male-sterile stocks to show any significant variability in expression of male-sterility over the three planting dates. When the same male-sterile stocks were crossed with the series of fertility differential testers, a number of the F_1 populations proved to be markedly influenced in expression of the male-sterile character by date of planting.

An experiment was conducted to test individual plants of lines Hy and C.1.7 for presence of reported relic heterozygosity of fertility restoring genes. No evidence for heterozygosity at such loci was found in any of the Hy or C.1.7 plants outcrossed to male-sterile inbred lines.

A comparative morphological study of the incompletely male-sterile single cross M1984 x M14 with the fertile reciprocal cross M14 x M1984 indicated that approximately eight days following meiosis a marked depression occurred in the growth rate of the anthers of the incompletely male-sterile single cross, both in length and in width.

[1]Doctoral thesis no. 1502, submitted January 14, 1954. Chairman of Committee, G. F. Sprague, Department of Agronomy.

[2]B.S., North Dakota State College, Fargo, N.D., 1949. M.S., Ibid., 1951. Graduate Assistant, Agricultural Experiment Station.

At the same period there was a significant difference between pollen grain diameter in the two crosses. Further growth and development ceased in about one-half of the pollen grains in M1984 x M14.

An hypothesis was formulated whereby the incomplete male-sterility of M1984 x M14 was explained as the expression of a single gene in conjunction with a specific cytoplasmic factor. The gene is apparently pleiotropic in effect, one expression of which is the reduced growth and development of the anthers, and the second being the cessation of growth and development of microspores bearing the dominant allele. Deviations from expectation encountered in the F_2 and backcross populations are attributed to the action of modifier genes, which apparently have a marked effect on the expression of the male-sterile character.

The Vg and the Reid sources of cytoplasmic male-sterility seemed to have a similar interaction of the cytoplasmic components with the genotype of six lines chosen as possible fertility restorers. On the basis of preliminary genetic investigations, a working hypothesis is presented, assuming that a male-sterile plant involving either the Vg or Reid type is of the genotype SS or Ss accompanied by the cytoplasmic factor. An inbred line which restores fertility in the F_1 generation bears a dominant allele designated as S'. Some type of selective fertilization is involved when using the heterozygote of the genotype SS' as the pollen parent.

Further genetic studies are suggested on the manner of inheritance of the male-sterile character in the M1984 x M14 single cross and in the Vg and Reid sources of cytoplasmic male-sterility.

NUCLEATION OF CRYSTALS OF SPARINGLY SOLUBLE SALTS[1]

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Volmer considered the crystal nucleus to be the agglomerate of ions or molecules of just sufficient size to be stable in a separate phase in contact with solution of a given degree of supersaturation. By using reasonable values of interfacial tensions, it is calculated that crystal nuclei consist of one-hundred or more molecules.

Recent work, based on the kinetics of precipitation, has led to the conclusion that a very small number of ions is involved in the nucleus of silver chromate, calcium fluoride, and barium sulfate. In every investigation to the present time, nucleation has been treated as a process totally separable from the growth process. This assumption is based on the association of nucleation with the induction period in precipitation reactions.

In this work the formation of crystal nuclei is considered to be a process competitive with growth of these nuclei. The size of the nucleus is defined by the kinetic order in ions or molecules of the nucleation reaction. The relative rates of nucleation and growth are estimated by counting the number of crystals obtained from a given supersaturated solution. Effects of variation in degree of supersaturation on the number of crystals obtained allows a determination of the number of each kind of ion per nucleus providing a growth rate is known or assumed. Variation of the number of crystals with temperature allows determination of the relative activation energies for nucleation and growth.

The theory outlined above has been tested with three different compounds: tetraphenylarsonium permanganate, tetraphenylarsonium perchlorate and nickel nioxime. The results for nickel nioxime are the most complete, and they show that either the nucleation mechanism, or the growth mechanism, or both, is dependent on which precipitating reagent is in excess. The values of ΔH_{diff} obtained from experiments with tetraphenylarsonium perchlorate indicate that the above fact is also true for that salt. The results obtained from data concerning tetraphenylarsonium permanganate are not considered reliable because of evidence of side reactions during the precipitations.

[1]Doctoral thesis no. 1489, submitted December 14, 1953. Chairman of Committee, Frederick R. Duke, Department of Chemistry.

[2]B.S., University of Oklahoma, Norman, Okla., 1950. Research Assistant, Institute for Atomic Research.

The method of estimating the number of crystals produced in precipitation of nickel nioxime was different from that used for the other two salts.

In runs producing the tetraphenylarsonium salts, the number of crystals per liter was found from the average volume per crystal. With nickel nioxime, N was found by direct count of the crystals in an aliquot of reaction mixture. The later procedure is much better, for it eliminates many errors which occur in the former.

THE FREE ENERGIES OF COMPLEX FORMATION AND OF ACTIVATION FOR THE REACTION OF PERIODATE ION WITH GLYCOL[1]

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The kinetics of the periodic acid cleavage of ethylene, propylene, meso- and levo-butylene and trimethylethylene glycols, and of pinacol were investigated, with the following objectives:

1. To determine the rate and equilibrium constants for a series of glycols, and the thermodynamic functions for complex formation and for activation.
2. To investigate the variation in rate of reaction with pH, in an attempt to explain the previously reported anomalous behavior of pinacol.
3. To ascertain whether or not a relationship might exist between the equilibrium constant for complex formation and the rate constant for disproportionation of of the complex.
4. To obtain more information about the nature of the reactive species.

Rates of oxidation of the above glycols were determined at 0°C and another temperature. The analytical technique used in most cases involved quenching a reaction aliquot in a bicarbonate-buffered solution of potassium iodide containing excess standard sodium arsenite. The excess arsenite was titrated with standard iodine solution to determine the total periodate, P_T, at the time of sampling.

All of the glycols except pinacol reacted according to the mechanism:

$$IO_4^- + \text{Glycol} \underset{\text{rapid}}{\overset{K}{\rightleftharpoons}} \text{Complex} \xrightarrow[\text{slow}]{k} \text{Products.}$$

The variation of rate with acidity for these glycols was demonstrated to be explainable on the basis of the availability of negative periodate ion, presumably IO_4^-.

Rate (k) and equilibrium (K) constants were determined, and the thermodynamic functions at 0°C calculated and tabulated. There appeared to be no systematic relationship between the rate and equilibrium constants.

The rate of oxidation of pinacol in acid solution was shown to be given by the expression:

$$-\frac{dP_T}{dt} = (k_o + k_H [H^+])\,[IO_4^-]\,[\text{Glycol}] .$$

Rate constants k_o and k_H were determined at two temperatures and the activation energies estimated on the basis of a bimolecular reaction between a glycol species and IO_4^-. It was suggested that the pinacol oxidation proceeds through preliminary formation of a mono-periodate ester.

[1]Doctoral thesis no. 1437, submitted July 15, 1953. Chairman of Committee, Frederick R. Duke, Department of Chemistry.

[2]B.S., University of Akron, Akron, Ohio, 1948. Research Assistant, Industrial Science Research Institute.

TITRATIONS INVOLVING COBALT IN ETHYLENEDIAMINE SOLUTION[1]

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Of the various volumetric methods for the determination of cobalt, probably the most widely used is the ferricyanide titration using ammonia as the complexing agent for the cobaltic ion. The method has been applied with success to the analysis of steels, ores, and non-ferrous alloys. In practice, the titration is followed potentiometrically and the back titration of excess ferricyanide with cobalt nitrate is recommended. The potential break at the equivalence point is about 0.2 v. and citrate must be added to prevent the precipitation of various other metal hydroxides. Manganese is the principle interfering element.

The present thesis is concerned with an improvement on the ferricyanide titration of cobalt by replacement of ammonia with ethylenediamine. The advantages in using ethylenediamine in place of ammonia were readily apparent. The cobaltous-ethylenediamine complex is a stronger reducing agent by some 0.5 v. than the corresponding ammonia-cobalt system; the potential break at the equivalence point in the titration is thus augmented by a similar amount. The determination can be carried out as a direct titration in most cases. If a suitable complexing agent is used cobalt may be determined in the presence of manganese.

As in the titration using ammonia, the presence of the salt as well as the free amine is essential. If ethylenediamine alone is present the potential drifts seriously; when both free diamine and its salt are present the potential rapidly reaches a steady state. The ethylenediammonium salt is conveniently formed in situ by neutralizing the acid remaining after dissolution of the sample.

The experimental procedure calls for dissolution of the sample in nitric and hydrochloric acids, and subsequent fuming with perchloric acid to remove nitric acid. The residue is then cooled, diluted, and boiled for several minutes. If chromium is present hydrogen peroxide is added to reduce this element to the chromous ion; excess peroxide is removed by boiling. The cooled solution is transferred to the titration vessel and either citrate or sulfosalicylate added as required. Nitrogen is bubbled through the solution for 15 minutes to remove dissolved oxygen. Ethylenediamine is then added and the solution titrated with 0.01 N potassium ferricyanide. The titration is followed potentiometrically using platinum and saturated calomel electrodes.

The present method was applied with success to a representative stainless steel and to a series of cobalt bronzes. The direct titration was applicable in all cases except that of a silver-bearing cobalt bronze. In this instance it was found that the cobaltous-ethylenediamine complex reduced silver to the metal, and redissolution of the silver during the titration with ferricyanide gave erratic results. For this reason the back titration of excess ferricyanide with cobalt sulfate was used.

The choice of complexing agent for ferric iron is dependent on the composition of the sample. If manganese is absent, citrate may be used to prevent the precipitation of metal hydroxides in alkaline solution. In the presence of manganese, however, citrate cannot be used; the manganese-citrate complex is oxidized by ferricyanide and this oxidation occurs concomitantly with that ot the cobaltous-ethylenediamine complex. Sulfosalicylic acid effectively complexes ferric iron and permits the successive titration of cobalt and manganese in the same sample; manganese is oxidized to the trivalent state in the process.

The determination of cobalt in Bureau of Standards 153 steel was studied extensively. This steel contains macro amounts of chromium, vanadium, molybdenum, tungsten, and cobalt, and smaller amounts of manganese and phosphorus. The peroxide reduction of chromium could not be used due to the formation of stable peroxy acids of tungsten and molybdenum which interfered in the titration. Use of sulfosalicylate was ruled out since this reagent reacted with dichromate in acid solution. Furthermore, the direct titration procedure was inapplicable due to the interference of three-component mixtures of tungsten, vanadium, and chromium. The partial solution to the problem of determining cobalt in this steel was to use citrate as the complexing agent and back

[1]Doctoral thesis no. 1542, submitted June 2, 1954. Chairman of Committee, Harvey Diehl, Department of Chemistry.

[2]A.B., Amherst College, Amherst, Massachusetts, 1950. M.S., Iowa State College, Ames, Iowa, 1952. Research Fellow, Industrial Science Research Institute.

titrate excess ferricyanide with cobalt sulfate. Fair precision was obtained by this method. No separations were necessary prior to the titration and the method is rapid. The complex nature of the steel would account for the failure to obtain better precision; results ranging from 8.18–8.51 per cent cobalt were obtained, while the accepted value is given as 8.45 per cent.

The second part of this thesis was concerned with the use of ethylenediamine solutions of cobalt sulfate as reducing agents for organic and inorganic compounds. The formal reduction potential for the cobaltous-cobaltic couple in ethylenediamine solution was found to be approximately -0.25 v. Hence, cobalt sulfate in ethylenediamine solution was expected to reduce dichromate, permanganate, and other similar oxidizing agents.

No reaction was observed between ethylenediamine solutions of cobalt sulfate and the following anions: chromate, molybdate, vanadate, stannate, uranate, and arsenate. The titrations with cobalt sulfate were run at room temperature and were followed potentiometrically. In the case of chromate, a calculation indicated that a reaction should have occurred; apparently kinetic phenomena are involved. The reduction potentials of the other anions studied are so lowered in alkaline solution as to render reduction by the cobaltous-ethylenediamine complex unlikely.

Permanganate was found to react with cobalt sulfate in ethylenediamine solution. Some oxidation of organic matter was observed and results for permanganate were not stoichiometric. A solution to this problem was found by adding permanganate to an acid solution of ferricyanide and back titrating the ferricyanide so produced. Phosphate was added to prevent the reoxidation of manganous ion by ferricyanide in alkaline solution.

No reaction was observed between copper or mercury and cobalt sulfate in ethylenediamine solution. Apparently the bivalent complexes of these metals with ethylenediamine were not reduced to the corresponding monovalent complexes. Reduction of mercury to the free metal by treatment with cobalt sulfate in ethylenediamine solution was likewise ineffective. Silver was reduced to the metal, but the reaction was so slow as to be useless as an analytical method.

The attempted reduction of organic nitro compounds with cobalt sulfate in ethylenediamine solution met with failure. Picric acid and p-nitrophenol failed to react with this reagent at reflux temperatures. The cause of this is thought to lie with the pH dependence of organic reductions.

SPECTROPHOTOMETRIC DETERMINATION OF THORIUM WITH THE TRISODIUM SALT OF 2-(2-HYDROXY-3, 6-DISULFO-1-NAPHTHYLAZO)-BENZENEARSONIC ACID AND SOME PROPERTIES OF COMPLEXES INVOLVED[1]

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The sodium salt of 2-(2-hydroxy-3, 6-disulfo-1-naphthylazo)-benzenearsonic acid, hereinafter referred to as thorin, has been extensively employed as a reagent for the spectrophotometric determination of thorium in recent years. No studies of the nature of the reaction between thorin and thorium have been reported. In this work, an examination of some properties of the complexes involved has been initiated.

An investigation of the change in the absorption spectrum of the thorin with pH showed that as the hydrogens are removed from the arsono group the equilibrium is shifted toward the hydrazone form of the dye. Solutions of the reagent are stable at low pH, but at neutral and high pH values there is a change with time. Corrected pK values for the dissociation of the hydrogens of the arsonic acid were obtained from the data. The values were 3.36 and 7.92, about 0.5 lower than the potentiometrically determined values. The pH change of the absorption spectrum of the predominant complex in excess reagent showed that the maximum difference between the reagent and

[1]Doctoral thesis no. 1380, submitted April 9, 1953. Chairman of Committee, Charles W. Banks, Department of Chemistry.

[2]B.S., Southeast Missouri State College, Cape Girardeau, Mo., 1947. Research Assistant, Institute for Atomic Research.

complex absorption occurs at low pH values, in the vicinity of 1.00, and in the region of 540 mμ. Subsequent studies were made at pH of 1.00. At neutral and higher pH values, the absorbance changed with time. At a low pH the solutions were stable.

A time study on a series of solutions prepared according to Job's method of continuous variations was carried out. The concentrations employed were 10^{-5} to 10^{-4} M. On standing the absorbance increased slightly at first, then levelled off for several days, and finally a precipitate developed in all solutions in which the molar ratio of thorin to thorium was less than four to one. Apparently this several day interval of constant absorbance was a metastable equilibrium state.

A Job's plot of the data indicated the predominant species was one having a ligand to metal ratio of 3:2. Titration of thorium solutions with thorin solutions, at concentrations of approximately 10^{-2} M, to the point of solution of the precipitate initially formed also indicated this ratio. Failure to obtain identical molar absorptivities in an excess of either reactant suggested the presence of several complexes. The charge on all complexes appeared to be negative, but the results were not conclusive.

Plots of absorbance data from series of solutions prepared according to the molar ratio method were made. Efforts to fit dissociation constants for several postulated equilibria to these data were unsuccessful.

The precipitate was isolated, dried at 105°C for several days, and analyzed for thorium, nitrogen, and water. The results showed it to be a compound containing two waters of crystallization in which the molar ratio of thorin to thorium was 1:1.

The optimum conditions for the spectrophotometric method were established. Methods for determining from 20 to 2,000 μg thoria were developed. The principal cation interferences are iron(III), bixmuth(III), rare earths, uranium(IV and VI), titanium(IV), and chromium(III). Principal anion interferences are phosphate and sulfate.

A rapid method for the determination of thorium in monazite sands was developed. The procedure involves (1) fusion of the sand with potassium hydrogen fluoride and separation of the insoluble rare earth and thorium fluorides by centrifugal action, (2) solution of the fluorides in a saturated aluminum nitrate solution acidified with nitric acid, (3) extraction of the thorium into mesityl oxide and reextraction into water, and (4) the spectrophotometric determination of the thorium in the extract with thorin.

SOCIOMETRIC SCORES OF HIGH SCHOOL STUDENTS AND THEIR RELATIONSHIP TO SELECTED VARIABLES OF FAMILY LIVING[1]

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This study was an exploratory study of social acceptance scores and their relationships to the family variables of socioeconomic status and place or residence (farm or town). The study was designed to contribute to the development of a North Central Region Cooperative Study on "Family influences on personality development."

In this research answers were sought to specific questions, including: 1. What is the degree of stability of the high school group's acceptance of its members over periods of one, two, and three years; 2. What is the relation between the student's acceptance by the high school group and: (a) the socioeconomic status of his family, (b) level of educational maturity, (c) place of residence and sex, (d) place of residence and sex with socioeconomic status and level of educational maturity held constant, and (e) socioeconomic status and level of educational maturity by place of residence and sex.

Method of Procedure

The study was conducted in a rural high school located in a small town in Eastern Nebraska, which had been selected on the basis of criteria designed to insure the typicality of the school and community. The student enrollment approximated 100, and the

[1]Doctoral thesis no. 1563, submitted June 8, 1954. Chairman of Committee, Ray E. Wakeley, Department of Economics and Sociology.

[2]B.S., Brigham Young University, Provo, Utah, 1935. M.S., Iowa State College, Ames, Iowa, 1948.

town population, 1,000. Slightly over one-half of the students lived on farms and had attended the first eight grades in one-room rural schools.

A four-item sociometric test developed by Dr. Ruth Staples was used to measure the group's acceptance of the students. The number of choices on each item was not limited. The test was given at yearly intervals during four consecutive school years, 1949-50 to 1952-53.

The family socioeconomic status rating was the composite of the ratings made by four residents of the community selected to act as judges. The Hermann Socioeconomic Status Scale was used for one year, but was found unsuitable for the purposes of this research. A zero order correlation coefficient between the ratings by the judges and the Hermann Scale produced an r of 0.430 (N = 103, 1 per cent level). The r obtained between the Hermann ratings and social acceptance scores of 103 students was 0.021. Coefficients ranging from 0.314 to 0.681 were obtained between ratings by the individual judges, (N = 125, 1 per cent level).

To measure the degree of stability of social acceptance scores zero order correlation was used. The significance of the changes in mean scores between the various grades was determined through the use of the "t" test.

Statistical analysis was simplified by dividing students into four sub-groups: farm girls, farm boys, town girls, and town boys, and the number in each group was reduced to 79 through sampling (the number of students in the sub-groups ranged from 79 to 114). Other statistical measures used included partial and multiple correlation, chi square, and covariance.

Findings

In spite of a general tendency for social acceptance scores to increase as students progressed through the high school (several of the differences between class means were statistically significant), the degree of stability of the acceptance scores was high as measured by zero order correlation. Scores received by the members of nine classes on tests given a year apart produced r's which ranged from 0.706 to 0.934. For an interval of two years, the r's for four classes ranged from 0.607 to 0.907. The r obtained for one class between scores on tests given three years apart was 0.835.

Social acceptance scores and family socioeconomic status were positively and significantly related for the total student group when level of educational maturity was held constant through partial correlation. The r equaled 0.388 (N = 316, 1 per cent level). However, distinct differences were found between farm and town students with respect to this relationship which was significant for farm students but not for town students. The r values were town girls 0.575, town boys 0.501, farm boys 0.127, and farm girls 0.056 (N = 79 for each subgroup).

The acceptance scores averaged for the 158 farm students 16.9, for the 158 town students 24.5, for 158 girls 21.8, and for 158 boys 19.6. Covariance was used to hold socioeconomic status and level of educational maturity constant. The differences between the scores received by farm and town students and boys and girls were statistically significant.

Farm girls received a smaller proportion of their acceptance choices from boys than town girls, and farm boys received a smaller proportion of their acceptance choices from girls than town boys. Chi square analysis produced significant differences.

Social acceptance and level of educational maturity were significantly related for the total group, farm boys, and town boys, but not for farm and town girls. Partial correlation was used to hold socioeconomic status constant. The r's were: total group 0.223, farm boys 0.308, town boys 0.277.

The relationship between social acceptance, socioeconomic status, and level of educational maturity was determined through the use of multiple correlation. The r's obtained were statistically significant for the total group 0.439, town girls 0.607, town boys 0.543, farm boys 0.335, and farm girls 0.223.

Discussion of Findings

The substantial relationship found between the social acceptance scores for periods of one, two, and three years may reflect the effect of the size of the high school and the community, on the basis of the extent to which the school and community approach the concept of the primary group. The apparent paradox of significant changes in the means of class scores between grades and the high degree of stability as measured by correlation is resolved when it is realized that correlation is essentially a measure of

ratio of two variables and that scores can increase proportionally from one year to the next and hence maintain a high stability in the sense of relatedness of scores, even though substantial changes have occurred in the actual social acceptance scores. The unlimited number of choices allowed students on the tests and the fact that the test contained more than one or two items may have contributed to the degree of stability found.

The difference between boys and girls in respect to social acceptance is statistically significant but the actual difference is so small that it probably lacks social significance. The substantial difference between farm and town students illustrates the difference in their situation when they enter high school. This difference may also reflect the more limited opportunity which farm students have for association with their age mates in the rural school.

The distinct differences between farm and town students with respect to the relationship of social acceptance and socioeconomic status suggests the possibility that the farm student is more on his own in the high school and that awareness or lack of awareness of the farm student's family socioeconomic status may be the factor involved.

CONCLUSIONS

The conclusions directly apply to the students, the high school, and the community included in this study. The possibility that similar results would be discovered in additional studies conducted under like conditions is suggested by the fact that the high school and rural community where this study was made are typical of high schools and rural communities of comparable size and composition in Nebraska and other parts of the Middle West. Each conclusion is supported by statistical findings of the study.

1. The acceptance scores of high school students increase as the students progress through high school. In spite of the changes over time, the stability of the group's acceptance of its members persists for periods of one, two, and three years.
2. The acceptance of town students by the high school group is positively related to the socioeconomic status of their families.
3. The acceptance of farm students by the high school group is not related to the socioeconomic status of their families.
4. Farm students are less well-accepted by the high school group than town students.
5. Boys are less well accepted than girls by the high school group.
6. Farm students received a smaller proportion of their acceptance choices than did farm students from members of the opposite sex.
7. The acceptance of students by the high school group, the socioeconomic status of their families, and their level of educational maturity were positively related. This relationship was also found for the sub-groups of farm girls, farm boys, town girls, and town boys.

CYTO-HISTOLOGICAL RESPONSES OF PLANT MERISTEMS TO MALEIC HYDRAZIDE[1]

JOHN BERNARD CARLSON[2]
Department of Botany and Plant Pathology

This study was undertaken to investigate the morphological responses of the seedling meristems of three crop species: oats, Avena sativa L., var. Shelby; maize, Zea mays L., yellow, dent hybrid Ohio C-92; and soybeans, Glycine max (L) Merr., var. Hawkeye, to maleic hydrazide (MH).

Seeds of these plants were treated by soaking in aqueous solutions of 0.025, 0.05, 0.1, and 0.2 per cent MH at 8°C. Some seeds were soaked in water as checks. Oats and maize were soaked 48 hours, and soybeans 24 hours.

After soaking, the seeds were germinated by one of two methods. Some seeds were planted in pots filled with a fertilized loam and placed in the greenhouse. Seeds were

[1]Doctoral thesis no. 1432, submitted July 12, 1953. Chairman of Committee, John E. Sass, Department of Botany and Plant Pathology.

[2]B.A., St. Olaf College, Northfield, Minnesota, 1950. Graduate Assistant.

also planted in moist Sphagnum moss in plastic germination chambers and placed into a 20–30°C germinator.

No decrease in germination percentage results from MH treatment at the concentrations used, but there is a one or two day delay in the emergence of the radicles and shoots of the treated seeds. Both root and shoot growth are much retarded, and root growth is inhibited more than shoot growth.

An increase in size occurs in root and plumular organs. Many root tips become bulbous, and shoots become much enlarged. Thickening of the coleoptile, seminal leaves and stem apex of oats and maize occurs. A similar thickening occurs in the seminal leaves and stem apex of soybeans. This enlargement of the organs of the three species is due to an extensive vacuolation and enlargement of the cells of all tissues of the seedling, associated with an increase in intercellular space. The nuclei of the enlarged cells are also abnormally large.

Some starch is normally present in the leaves, stems and roots of untreated plants of oats, maize and soybeans, except at oat roots. In treated plants a considerable accumulation of starch is present in these tissues. Starch is also found in the youngest cells of the stem and root apices of treated plants.

Roots may develop hairs to the tip and have mature vascular tissues up to 0.1 mm. of the tip. Mature vascular tissues occur also in leaf primordia. Soybean stem tips have epidermal hairs on the tunica of the youngest leaf and on the apical meristem. The apices of the stem and root lose their meristematic function and produce no new tissues or organs.

For several days after the germination of seeds treated with 0.1 per cent MH, the growth of the seedlings is evidently due entirely to enlargement of the cells which were present in the dormant embryo. No mitosis was noted up to seven days in maize, or up to ten days in soybeans. Mitosis did resume to a limited extent in oats at four to five days.

When mitosis is resumed in oats, mitotic abnormalities become apparent. Extensive breakage of chromosomes occurs. Chromosomes and fragments of chromosomes are lost on the spindle or move into the cytoplasm where they form micronuclei. Many bridges are formed, which may indicate chromosome stickiness. Chromosome breakage may be due in part to this stickiness. Cytokinesis appears to be normal, however, the daughter cells are multinucleate.

The foregoing observations describe the responses of seedlings developing from seeds treated while dormant. For comparison, an experiment was designed to investigate the effects of MH on tissues that were treated during active growth. Seeds of oats, maize, and soybeans were germinated on wet blotting paper at room temperature. When the primary roots were about two centimeters in length, the seeds were transferred to germination chambers kept at 25°C and containing blotters wet with 0.05 per cent MH. Collections for cytological study were made periodically.

Mitosis is inhibited by MH treatment. Frequency of mitosis in actively growing tissues drops very quickly after exposure to MH. After four hours of exposure to MH, mitotic frequency in root tips drops to 30–40 per cent of the check, and by 48 hours, mitotic activity ceases completely. Chromosome breakage and bridges occur.

The volume of the nucleoli of root tip tissues increases greatly after exposure to MH. This increase in volume is attributed to an increase in the food supply of the root tip, as shown by starch accumulation. Persisting nucleoli are found throughout the entire mitotic cycle, presumably a direct result of the increased nucleolar volume.

There are no visible changes in the mitochondria after MH treatment.

Extensive cell enlargement, the formation of root hairs to the extreme tip, and "precocious" vascularization become evident, similar to the responses of seedlings developing from seeds treated while dormant.

SOME STUDIES ON THE URANIUM-THORIUM-ZIRCONIUM TERNARY ALLOY SYSTEM[1]

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Department of Chemistry

Alloys of the uranium-thorium-zirconium system have been investigated by thermal, microscopic and X-ray methods. The uranium-thorium binary system has been studied and a phase diagram proposed. In this system there is a eutectic at 1086°C and 3 weight per cent thorium. A region of liquid immiscibility exists above 1375°C between the compositions 8 weight per cent and 72 weight per cent thorium. A method of determining the boundary of the liquid area has been described. This method consisted, briefly, of maintaining the alloys at a constant temperature allowing the two liquid layers to separate and determining the composition of each layer by chemical analysis. The thorium liquidus, which rises sharply from the eutectic, was determined in a similar manner. Excess solid thorium was immersed in molten uranium at fixed, elevated temperatures until equilibrium was established. From chemical analysis the amount of thorium dissolved was ascertained establishing a point on the liquidus curve. No solid solubility was observed in either component and no intermetallic compounds were found.

The thorium-zirconium binary system has also been investigated and a phase diagram, likewise, has been proposed. There is a minimum in the solidus-liquidus curves at 1275°C and 25 weight per cent zirconium. The solid solubility of zirconium in thorium has been estimated from X-ray measurements and from microstructures to be about 5 weight per cent zirconium. The solubility of thorium in alpha zirconium appears to be negligible. Above 900°C in the region of beta zirconium the solid solubility in either component is more extensive. Microscopic examination of alloys quenched from above 900°C indicates that a continuous solid solution region lies beneath the solidus line. Some evidence for a high temperature allotropic form of thorium has been presented and its possible existence discussed. There is eutectoid at 70 weight per cent zirconium and 645°C. No compounds which are stable at room temperature were observed.

The literature of the uranium-zirconium system has been reviewed. Beta zirconium and gamma uranium have been reported to exhibit extensive solid solubility in one another. Present investigations indicate that a eutectoid point exists at 687°C and approximately 10 weight per cent zirconium.

A preliminary survey of the ternary alloy system has failed to reveal a minimum in the liquidus of the three component system.

[1]Doctoral thesis no. 1051, submitted June 5, 1850. Chairman of Committee, Harley A. Wilhelm, Department of Chemistry.

[2]B.A., Yankton College, Yankton, South Dakota, 1943. Research Assistant, Institute for Atomic Research.

HISTOCHEMICAL REACTIONS IN VERTEBRATE TESTES[1]

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A comparative histochemical study of vertebrate testes was carried out on sexually mature males representing the classes Mammalia, Aves, Reptilia, Amphibia, and Pisces. Lipid and periodic-reactive carbohydrate distribution were examined as to their morphological localization in the bull, ram, rat, guinea pig, rooster, the horned lizard, Phrynosoma cornutum (Harlan), the frog, Rana pipiens, and the bluegill fish, Lepomis macrochirus Rafinesque.

In order to demonsrate the lipid components of the vertebrates studied, the follow-

[1]Doctoral thesis no. 1529, submitted May 18, 1954. Chairman of Committee, Robert M. Melampy, Department of Animal Husbandry.

[2]B.A., Texas Technological College, Lubbock, Texas, 1949. M.A., Ibid., 1951. Associate, Industrial Science Research Institute.

ing methods were employed: Sudan black B, oil red O, the Ashbel-Seligman reaction, the Schultz test for cholesterol, polarization microscopy after digitonin treatment, and Baker's acid hematin test for phospholipids. For the localization of periodic acid-reactive carbohydrates, the staining technique was the periodic acid-Schiff method(PAS).

Following use of the Sudan dyes, lipids were noted in the interstitial cell cytoplasm, the basement membrane, and the cytoplasm of the Sertoli cells, spermatogonia, spermatocytes, and spermatids of all species studied with the exception of the bluegill fish. In the bluegill, lipids were visible in the germ cells and in the interlobular connective tissue sheath. A positive Ashbel-Seligman reaction was obtained in the Leydig cells of all species examined, except in the case of the rooster and the fish. With the aid of Baker's acid hematin test, phospholipid was found in the testicular cell types of the species studied. This method was not applied to the bluegill fish testis. Schultz-positive material was noted in the Leydig cells of the bovine, ram, rat, guinea pig, horned lizard, and frog. Birefringent crystals were present in the Leydig cells and seminiferous tubules of the frog.

In this investigation, the comparable results obtained as to lipid localization in the various species studied suggest the possible widespread distribution of these substances in the Leydig, Sertoli, and germ cells of closely related species as well as those which are even more distant in taxonomic classification.

The chemical nature of substances giving a positive PAS reaction has been discussed. With the aid of the PAS technique, glycogen was identified in the tunica albuginea of Phrynosoma cornutum; in the Leydig, Sertoli, and germ cells of the lizard and frog, as well as in the connective tissue sheath on the bluegill fish testis. Schiff-positive material was localized in the interstitial cells, walls of blood vessels, basement membrane, and the cytoplasm of the Sertoli and germ cells of the various species examined with exception of the fish. In the case of the latter species, PAS-positive staining was visible in the interlobular connective tissue. The acrosomic system, arising in the idiosome and forming the acrosome of spermatozoa, was described in the bovine, ram, rat, guinea pig, chicken, and horned lizard.

The possibility is suggested that the four phases of spermiogenesis, as observed with the PAS technique (Golgi, cap, acrosome, and maturation phase), might be found in even more diversified species than those studied in this investigation.

THE METABOLISM OF GLUCOSE BY PSEUDOMONAS AERUGINOSA[1]

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Washed cells of Pseudomonas aeruginosa oxidize glucose, gluconate and 2-ketogluconate to a comparable degree. Iodoacetate and fluoride do not influence these oxidations at concentrations which inhibit the oxidation of glucose and gluconate by Escherichia coli. The difference in activity of these inhibitors reflects a difference in the metabolism of these compounds by these two organisms. Low concentrations of fluoride actually stimulate the uptake of O with glucose and gluconate by Pseudomonas aeruginosa sufficiently to account for the complete oxidation of these two compounds.

Pseudomonas aeroginosa will not form acid anaerobically from glucose or 2-ketogluconate, whereas Eschericia coli will form acid from glucose. This may be taken as indication of the absence of a glycolytic scheme in Pseudomonas aeruginosa and shows a difference from Escherichia coli which is known to possess such a scheme.

Cell-free extracts of Pseudomonas aeruginosa will form 2-ketogluconate from glucose and gluconate. 2-Ketogluconate is not metabolized. With radioactive glucose as a substrate, gluconate has been shown as an intermediate in the conversion to 2-ketogluconate. No other products were detected by paper chromatographic and radioautographic techniques. This conversion does not involve phosphorylated intermediates. The cell-free extracts will metabolize glucose-6-phosphate, but the activity on this

[1]Doctoral thesis no. 1465, submitted December 1, 1953. Chairman of Committee, C. H. Werkman, Department of Bacteriology.

[2]B.A., University of British Columbia, Canada, 1943. Instructor. Graduate Assistant, Industrial Science Research Institute.

compound can be removed by extensive dialysis leaving the system forming 2-ketogluconate from glucose intact. No coenzyme or cofactor requirements have been demonstrated. The oxidation of glucose and gluconate occurs at an optimum of pH 6.5 to 6.8. Cyanide is a powerful inhibitor of this reaction giving evidence for the possible presence of a cytochrome-type carrier.

Pseudomonas aeruginosa cell-free extracts will phosphorylate glucose and gluconate which indicates the presence of the enzymes hexokinase and gluconokinase. However, kinases for the compounds galactose, mannose, fructose, 2-ketogluconate, ribose, xylose, and arabinose are absent. In addition to the two kinases, the glycolytic enzymes aldolase and triosephosphate dehydrogenase were found. The optimum activity for aldolase was at pH 8.3.

Coenzyme I was reduced in the presence of hexose-diphosphate, glycose-6-phosphate, ribose-5-phosphate, and fructose-6-phosphate but not with gluxose-1-phosphate, gluconate, 2-ketogluconate, glucose, ribose, or arabinose. A similar situation occurred with Coenzyme II except that in the presence of hexose-diphosphate the reduction was almost instantaneous and with ribose-5-phosphate there was no reduction.

Because cell-free extracts are inactive upon 2-ketogluconate, whole cells were used to study the further metabolism of this compound. Radioactive glucose was prepared by photosynthesis and then converted to 2-ketogluconate by the cell-free preparation of Pseudomonas aeruginosa. The 2-ketogluconate was separated by paper chromatography and radioautography. Whole cells were allowed to metabolize the labelled 2-ketogluconate for varying periods of time, the reaction stopped and deproteinized with acid, then the supernatant concentrated, separated into neutral, cationic and antionic fractions with ion exchange columns, and chromatographed on Whatman No. 1 filter paper. From the multitude of radioactive spots that appeared the following radioactive compounds have been identified: arginine, glutamic acid, alanine, lysine, histidine, cysteine, a leucine, citrate, succinate, lactate, fumarate, malate, α-ketoglutarate, pyruvate, malonate, dihydroxyacetone, glucose, phosphate, a nucleotide and other phosphate esters. In addition, several other radioactive compounds remain unidentified.

The identification of the amino acids is strong evidence for an assimilatory mechanism operative during the oxidation of 2-ketogluconate. The presence of the organic acids indicates the possibility of a tricarboxylic acid cycle for terminal respiration. The formation of malonate is interesting in the light of its role as an inhibitor of succinate oxidation.

The unidentified radioactive compounds do not appear to be common intermediates in known pathways of glucose metabolism. Their identification should prove of importance in the formulation of a mechanism for 2-ketogluconate oxidation. It is apparent that the metabolism of glucose by Pseudomonas aeruginosa is quite different from the accepted Embden-Meyerhof pathway known to be possessed by many organisms. However, several enzymes of this latter pathway have been detected and the possibility exists that more than one type of glucose degradation occurs in this organism.

HISTORY OF AGRONOMY AT THE IOWA STATE COLLEGE[1]

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The work in agronomy at the Iowa State College has made many notable contributions to the science and art of agriculture in Iowa and in the nation. The present study traces the development of these contributions from the opening of the college in 1869 to the present, 1953. The history of resident teaching in agronomy constitutes the main theme of the study.

The first faculty of the Iowa Agricultural College and Farm consisted of nine persons. From 1869 until 1891 there was usually one staff member in agriculture, and the largest number of bachelor's degrees granted in this field in a single year before 1900 was 14.

[1]Doctoral thesis no. 1445, submitted July 17, 1953. Chairman of Committee, John B. McClelland, Department of Vocational Education.

[2]B.S., Iowa State College, Ames, Iowa, 1943. M.S., Ibid., 1951. Instructor.

In the early years of the college there was no organized body of agricultural knowledge that could be systematically taught. Very few people anywhere in the United States were trained in the science of agriculture but a number of persons had received degrees in chemistry, physics, and other sciences. As a result there was a tendency to emphasize the sciences in the new agricultural curricula. However, two of the early professors of agriculture at the Iowa Agricultural College were employed because they had been successful as practical farmers.

The value of research in expanding the knowledge of agriculture was recognized early by individuals and groups in Iowa. The Iowa State Horticultural Society was especially vocal in urging that the college conduct research. Agricultural research started soon after the opening of the college. The passage of the federal Hatch Act in 1887 and the establishment of the Iowa Agricultural Experiment Station in 1888 gave great impetus to research work in agriculture.

From 1891 the number of staff members in agriculture gradually increased. In 1897 students in the senior year in agriculture were permitted to select courses from any one of four groups in the curriculum in agriculture. The following year, agriculture was made a division of the college and was subdivided into the five departments; namely, Practical Agricultura, Dairying, Animal Husbandry, Horticulture, and Agricultural Chemistry.

The Department of Agronomy, established in 1902, was the outgrowth of the Department of Practical Agriculture although work of an agronomic nature had also been included in other areas, particularly in the Department of Agricultural Chemistry.

Work in agronomy had not been especially emphasized at the college prior to 1891. From 1891 to 1902 the emphasis on work in this area increased. The new Agronomy Department started with prestige due to the appointment of P. G. Holden as head. Holden came to the college with a national reputation which he had made from his work in Illinois. He remained as the Head of the Department, which included work in farm crops, soils, farm mechanics, and farm management during that time, until 1906 when he became head of the extension work at the college.

M. L. Bowman was in charge of the work in farm crops from 1906 to 1909. W. H. Stevenson was in charge of the work in soils during this time. In 1909, Stevenson was designated the Head of the Agronomy Department and continued in this capacity until 1931. P.E. Brown succeeded to the headship and served until his death in 1937. W.H. Pierre has been the Head of the Department from 1938 until the present (1953). H. D. Hughes headed the work in farm crops from 1910 until 1947 when he retired from administrative responsibilities and was succeeded by I. J. Johnson who is presently serving in this capacity.

The farm crops and soils work was located in the first Hall of Agriculture (now Botany Hall) from 1902 to 1909. In the latter year the department moved to the new Hall of Agriculture (now Curtiss Hall). The department remained in this location until the completion of the new Agronomy Building in 1952.

The total number of farm crops and soils courses changed frequently during the years between 1902 and 1931. Since 1931 the agronomy courses have been more stable and the tendency has been for a small amount of expansion in the number of courses rather than the substitution of one course for another. Throughout the years from 1902 to 1953 the content of courses has been revised in order to integrate the new knowledge gained from research.

Students in agronomy were members of the Agricultural Club during the early years of the department. This club included students from the entire Division of Agriculture. About 1915 the Agronomy Club was established. In 1932 this organization became the Student Section of the American Society of Agronomy.

Short courses have been an important part of the work in agronomy at the Iowa State College. In the first year of the department (1902) a short course in corn and grain judging was held. After 1925 short courses were offered in a greater number of specialized fields. The Soil Management and Land Valuation Short Course has been conducted continuously since 1925 with the exception of two years during World War II.

From 1910 to 1930, noncollegiate work in agronomy played an important part in the work of the Division of Agriculture. A number of noncollegiate courses in farm crops and soils were offered during these years. Usually one noncollegiate course in agronomy has been offered since 1930.

The first master's degrees in farm crops and soils were granted in 1905. Agronomy was one of the departments authorized to give work leading to the degree of Doctor of Philosophy when the Iowa State College was authorized to grant this degree in 1915. By

July, 1952, the total number of doctor of philosophy degrees that had been granted in all areas by the Iowa State College was 1,330. Of this number, 156, or 11.7 per cent, had been granted in agronomy. Graduate work by members of the staff was initiated in 1914. The first research fellow in agronomy was appointed in 1916.

The resident teaching staff in agronomy has been characterized by the relatively long tenure of its members during the years from 1902 to 1953. During the early years of the twentieth century it was a policy in the Division of Agriculture that staff members should devote full time in one of the areas of teaching, research, or extension. This policy gradually changed and for the last 20 years the majority of resident teaching staff members in agronomy have also been on the staff of the Iowa Agricultural Experiment Station.

CHROMOSOMAL ABERRATIONS IN OATS, AVENA SATIVA L. [1]

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The uses for monosomic and nullisomic stocks in genetics has made desirable the testing of methods for securing whole-chromosome deficiencies in usable and repeatable frequencies. The methods which have been used are not generally applicable, because they are associated with unusual properties of the species in which they have been used.

The method used by Clausen in Nicotiana tabacum requires that the species in which the monosomics are desired form fertile hybrids in which univalent chromosomes occur at meiosis, or that an asynaptic strain be available. Such a strain was available in a mutant, pale-sterile. The hybrid used was between N. tabacum and N. sylvestris. Such conditions are not to be had in most species in which the monosomics could be useful.

The other method which has had success is that of pollinating a haploid plant with pollen from a normal plant. This is the method used by Sears in Triticum aestivum (T. vulgare). The haploid is partially fertile owing to the formation of some type of restitution nucleus. Such eggs as do function, however, are not wholly normal because the restitution process is not perfect. Deficient eggs are formed and these produce, when united with normal sperm, zygotes which are monosomic for one or more chromosomes. This method cannot be used with all species because haploids are generally rare and cannot be produced at will. With few exceptions haploidy may be considered a wholly fortuitous occurrence.

What is needed is a method which can be used on any species which can tolerate whole-chromosome deficiency. The method used in these experiments was based on the production of dicentric chromosomes with the use of X-rays. Since the material used was cultivated oats, Avena sativa L., the method could not be used in conjunction with emasculation of the flowers, oat flowers being most difficult to manipulate successfully in artificial pollinations in adequate numbers. The method as finally used consisted in treating mature panicles just before anthesis with 300 r units. This treatment was a treatment of the egg nucleus and the sperm nucleus. The monosomes produced could have come from the induction of a dicentric chromosome in either nucleus. Most of the detected effect probably occurred in egg nuclei, since affected pollen grains certainly could have no advantage over unaffected grains, and probably were at a disadvantage in competition. The seed produced by the irradiated panicles was grown and its chromosome constitution determined by direct examination of the microsporocytes. The plants determined to be monosomic were retained and allowed to set seed by self-pollination. The progenies of these plants were examined for normal, monosomic, and nullisomic members.

The final yield, after irrelevant cytological anomalies such as inversions and translocations had been discarded, was twenty monosomes. This represented a yield of

[1] Doctoral thesis no. 1482, submitted December 10, 1953. Chairman of Committee, Joseph G. O'Mara, Department of Genetics.

[2] Eng. Agr. Instituti Superior de Agronomia, Portugal, 1943.

approximately seven per cent. The treatment is most probably not the optimum treatment for the purpose. It is, however, a practical one and should serve as the basis for attempts to discover a more efficient dosage. This, for the present purpose, may be defined as that dose which will produce the greatest ratio of monosomes to other cytological anomalies.

A STUDY OF ORGANOSILICON FREE RADICALS[1]

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Department of Chemistry

The chemistry of organic free radicals has received intensive study, but reports of organosilicon free radicals are relatively rare. The radical induced addition of substituted silanes to olefins has been reported (1). Accordingly, organosilicon free radicals were studied in this work in their role as reactive intermediates in order to gain information as to the similarities and differences in the reactivities of silicon and carbon free radicals.

The chain transfer constants of triethylsilane and triphenylsilane in the thermal polymerization of styrene were determined by the method of Mayo (2). At 70.00°, the chain transfer constant for triethylsilane was 2.44 ± 0.12; for triphenylsilane, 33.4 ± 1.2. At 80.05°, values of 1.3–2.7 and 36.8 ± 1.8 were obtained for triethylsilane and triphenylsilane, respectively. These values show a high reactivity of substituted silanes in chain transfer activity, and the appreciable differences in the chain transfer constants of triethylsilane and triphenylsilane suggest an appreciable reorganization energy of the triphenylsilyl free radical.

Oxidation of triphenylsilane to triphenylsilanol at 80° in benzene was found to be effected by benzoyl peroxide as the initiator. No peroxides or hydroperoxides were isolated from the reaction. The kinetics of the oxidation of triphenylsilane in chlorobenzene at 62.5 and 74.4° were studied by measuring the rate of oxygen uptake. Azo-bis-isobutyronitrile was used as the initiator. The rates were found to fall off from first order dependence on triphenylsilane as the reaction proceeded; this effect became more noticeable at the higher temperature, and at higher initial concentrations of triphenylsilane. The observation led to the formulation of a mechanism for the oxidation in which triphenylsilanol was isolated as the major product.

$$
\begin{aligned}
I &\longrightarrow X\cdot \\
X\cdot + O_2 &\longrightarrow XO_2\cdot \\
X\cdot \text{ (or } XO_2\cdot) + RH &\longrightarrow HX + R\cdot \\
R\cdot + O_2 &\longrightarrow RO_2\cdot \\
RO_2 + RH &\longrightarrow RO_2H + R\cdot \\
R\cdot + RO_2H &\longrightarrow RO\cdot + ROH \\
RO_2H &\longrightarrow RO\cdot + \cdot OH \\
RO\cdot + RH &\longrightarrow ROH + R\cdot
\end{aligned}
$$

The reaction of di-tert-butyl peroxide, triphenylsilane and chlorobenzene at temperatures of 128–137° was studied under a variety of conditions. The major product of this reaction proved to be triphenylchlorosilane. A mixture of o-chlorobiphenyl and p-chlorobiphenyl was identified as a product of this reaction by infrared spectroscopy. No evidence for a chain reaction of any length was found, since the reaction required equimolar quantities of the peroxide for highest conversions to triphenylchlorosilane. The rate of production of triphenylchlorosilane was found to fall off from the rate of decomposition of the peroxide as the reaction progressed; removal of volatile products during the reaction increased the yield of triphenylchlorosilane; introduction of benzophenone into the reaction mixture decreased the amount of triphenylchlorosilane formed. These observations suggest a process in which a triphenylsilyl radical is formed by hydrogen abstraction, and reacts with chlorobenzene to give a phenyl radical and

[1]Doctoral thesis no. 1560, submitted June 7, 1954. Chairman of Committee, Henry Gilman, Department of Chemistry.

[2]B.S., Southern Methodist University, Dallas, Texas, 1948. Graduate Assistant, Industrial Science Research Institute.

triphenylchlorosilane. The phenyl radical may then react with chlorobenzene to form the isomeric biphenyls. The inhibiting action of the reaction products and benzophenone suggests that these species compete with chlorobenzene for the triphenylsilyl radical. Similar reactions with fluorobenzene and bromobenzene as solvents gave products which hydrolyzed to produce acid; presumably these products were triphenylbromosilane and triphenylfluorosilane formed by a process analogous to the one suggested above. No hexaphenyldisilane was found as a product of any of the reactions listed above.

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THE VAPOR PRESSURES OF LANTHANUM AND PRASEODYMIUM[1]

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Department of Chemistry

A technique for preparing rare earth metals was devised in which their chlorides were reduced by calcium in tantalum vessels; the resulting metal was cast in tantalum molds to remove volatile impurities. Lanthanum and praseodymium were prepared in 20 gram batches with yields of 100 $\pm$ 1 per cent; a 90 $\pm$ 5 per cent yield of lanthanum was obtained on a 250 mg. scale. It was not possible to prepare samarium metal by reducing samaric chloride with calcium under the same conditions which were successful with lanthanum and praseodymium.

Gadolinium chloride, containing 1.7 per cent samaric chloride and 0.23 per cent europic chloride, was reduced with calcium to produce a 96 per cent yield of metal; samarium and eruopium were not detected in the product. This separation of samarium and europium from gadolinium is more convenient than are the ordinary chemical methods.

A technique for measuring vapor pressures of materials of low volatility was devised; this consisted of modifying Knudsen's effusion method by placing a quartz fiber balance inside of the vacuum apparatus to measure weight losses from the effusion vessel. To test this technique, the vapor pressures of copper and silver were measured; the results are in reasonable agreement with the accepted values in the literature.

The vapor pressures of lanthanum and praseodymium were determined over the range 10^{-2} to 10^{-4} mm Hg using the above technique. For lanthanum, the vapor pressure equation is

$$\log P = \frac{-17753 \pm 308}{T} + 6.816 \pm 0.166;$$

the heat of vaporization and extrapolated normal boiling point of lanthanum may be obtained from this equation, and are, respectively, -81.0 $\pm$ 1.4 Kcal. mole^{-1} and 4515° $\pm$ 150°K. For praseodymium the vapor pressure equation is

$$\log P = \frac{-17188 \pm 243}{T} + 8.098 \pm 0.156;$$

the heat vaporization and extrapolated normal boiling point are, respectively, -79.5 $\pm$ 1.1 Kcal. mole^{-1} and 3290 $\pm$ 90°K.

[1]Doctoral thesis no. 1136, submitted December 14, 1950. Chairman of Committee, F. H. Spedding, Department of Chemistry.

[2]B.S., University of Florida, Gainesville, Fla., 1941. Research Assistant, Institute for Atomic Research.

PREPARATION OF PERBROMATES[1]

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Perchlorates and periodates may be prepared by oxidation of chlorates and iodates with a number of commonly used oxidation methods. It would follow that perbromates, as indicated by well known facts about the halogen family, could be prepared by similar oxidation methods; however, this has never been accomplished. It has been suggested that the perbromates are too unstable to be made, or that the oxidation potential required to form them is extraordinarily high. However, no sound theoretical reasons have been found, as yet, that offer any explanation for the nonexistence of perbromates.

The methods of analysis for the detection or determination of the perbromate ion, although unknown, were assumed to be similar to well known tests for the perchlorate and periodate ions. The tests used for these ions, as well as the other halate or halide ions, include: (1) precipitation of insoluble inorganic salts – silver halides, silver bromate and iodate, silver periodate, and potassium perchlorate; (2) the liberation of iodine from potassium iodide and its subsequent titration with a thiosulfate solution, and (3) a number of organic reagents that are known to detect perchlorates and periodates. These organic reagents are methylene blue, Zwikker's reagent, brucine, nitron, benzidine, morphine, strychnine, tetraphenylarsonium chloride, 5-nitro-1, 10 phenanthroline ferrous sulfate, and manganous sulfate in phosphoric acid. These reagents were used as spot tests under a microscope, and occasionally polarized light was used to detect anisotropic crystals. The mixtures of chloride, chlorate, and perchlorate ions were analyzed by titrating the chloride with silver nitrate in one portion of the solution, in a second portion the chlorate was reduced with sulfur dioxide and the resulting chloride titrated, and a third portion was fused with sodium carbonate and the total chloride determined by titrating with silver nitrate.

In this work, attempts were made to prepare perbromates by oxidation with fluorine gas, ozone, chlorine gas, potassium and ammonium peroxydisulfates, sodium bismuthate, potassium and barium superoxides, sodium and potassium peroxides, and 90 per cent hydrogen peroxide. Anodic oxidation and autoxidation were also tride. Silver and cobalt ions were used as catalysts. Oxidation was attempted in aqueous solutions, liquid ammonia, ethyl alcohol, acetone, dioxane, ethyl acetate, and other organic solvents. The general procedure was to prepare peridates and perchlorates by the oxidation method to be used, and then attempt to prepare perbromates in a like manner.

Elemental fluorine gas, though difficult to handle, has the highest oxidation potential of any oxidizing agent. Fluorine passed into halate solutions readily formed periodates and perchlorates, but no perbromates were found. Under these conditions fluorine readily oxidized manganese to permanganates, sulfates to peroxydisulfates, and chromium to dichromates. The silver and cobalt ions were used as catalysts in part of the experiments with fluorine oxidation. Fluorine produced numerous luminous explosions as it reacted with the aqueous solutions. This, along with the ease with which fluorine reacts with water, caused some difficulty in using fluorine as an oxidizing agent.

Ozone was used in liquid ammonia, organic solvents, and aqueous solutions in attempts to oxidize the halates to the perhalates. Oxidation was slow due to the low concentration of ozone available, the slow reaction rates at the temperature of liquid ammonia, and the low solubility of salts in organic liquids. Methods of analysis were simplified with the use of ozone since excess ozone is easily removed by bubbling oxygen through the solutions.

Potassium and ammonium peroxydisulfates were heated with the halates in the dry state, boiled with the halates using the silver ion as a catalyst, and warmed with the halates in organic solvents. In the dry state, peroxydisulfates readily reduce the halates to the free halogen. Although perchlorates and periodates were formed, no perbromates could be detected.

A similar series of experiments were made using sodium bismuthate, sodium and potassium peroxides, barium and potassium superoxides, and 90 per cent hydrogen peroxide. In most of these experiments the excess peroxide content was difficult to

[1]Doctoral thesis no. 1492, submitted December 14, 1953. Chairman of Committee, John A. Wilkinson, Department of Chemistry.

[2]B.S., McPherson College, McPherson, Kansas, 1940. Instructor. Research Associate, Industrial Science Research Institute.

remove and limited the methods of analysis to spot tests and microscopic examination. Hydrogen peroxide reduces periodates and bromates readily and proved to be an unsuitable oxidizing agent for the halates.

A high concentration of fluoride ion was maintained in the anolyte in the experiments with anodic oxidation. This, in conjunction with a smooth platinum electrode, was used to develop a high oxygen overvoltage and helped produce optimum oxidizing conditions. Perbromates were not found to be formed by anodic oxidation.

Autoxidation of bromates was attempted and an automatic recording balance was used to follow the course of the reaction. Potassium chlorate was found to be completely oxidized to perchlorate by heating with sodium bromate. Some easily decomposed oxygen compounds were heated with bromates in a similar manner in order to form perbromates.

No evidence was found in any of the experiments to indicate the formation of perbromates; neither was any evidence found to support the conclusion that perbromates cannot be made.

Perbromates might possibly be formed by oxidation under conditions such as:
(1) oxidation in nonaqueous solvents, since perbromates may be unstable toward water;
(2) oxidation with an oxidizing agent with an extremely high oxidation potential;
(3) oxidation in the fused state with substances which liberate oxygen at a lower temperature than that at which the bromate decomposes – very high pressures of oxygen over the reaction mixture might be of value in this connection; or
(4) oxidation at low temperatures, since the perbromate may be stable only at low temperatures.

THE NIOBIUM–THORIUM AND THE NIOBIUM–VANADIUM ALLOY SYSTEMS[1]

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The niobium-thorium and the niobium-vanadium alloy systems were investigated by thermal, microscopic, X-ray, and electrical resistance methods. On the basis of the data obtained from these studies a phase diagram has been proposed for the niobium-thorium alloy system, and a phase diagram has been proposed for the niobium-vanadium alloy system.

A eutectic is formed between niobium and thorium at about 1435°C and 8 per cent niobium. There are no intermediate phases formed in the niobium-thorium alloy system. The extent of terminal solid solubility at room temperature was determined by X-ray diffraction studies. The solubility of niobium in alpha thorium is less than 0.1 per cent and the solid solubility of thorium in niobium is considered negligible. Since eutectic structure and a eutectic melting point were observed on a 1 per cent niobium alloy, the solid solubility of niobium in beta thorium is evidently less than 1 per cent. The addition of niobium to thorium lowers the reported alpha to beta transformation temperature (1400°C) of thorium slightly. This lowering might be due to a scavenging effect of niobium or to the formation of a eutectoid in that region of the phase diagram involving less than 1 per cent niobium. Although no microscopic evidence could be retained in these alloys, the possibility of a eutectoid is not ruled out.

Niobium forms a complete series of solid solutions with vanadium. The solidus curve of the niobium-vanadium alloy system has a long, nearly flat section extending from about 10 to 50 per cent niobium. The curve passes through a minimum at about 35 per cent niobium and the minimum temperature is approximately 1805°C. The liquidus curve lies very close to the solidus curve throughout the entire alloy system. In no instance was a temperature difference of more than 50°C observed between the solidus and the liquidus for the same alloy. Over a rather wide percentage range near the minimum, the liquidus curve appears to be almost identical with the solidus curve.

Niobium-vanadium alloys that were prepared using ductile niobium and vanadium

[1]Doctoral thesis no. 1390, submitted May 29, 1953. Chairman of Committee, Harley A. Wilhelm, Department of Chemistry.

[2]B.S., Iowa State College, Ames, Iowa, 1949. Research Assistant, Institute for Atomic Research.

were very easy to machine or to cold work. The alloys could be cold rolled to thin sheet without annealing and without serious edge cracking. Niobium-vanadium alloys have a slow rate of corrosion to hot distilled water at temperatures at least as high as 330°C. The corrosion rate of the alloys appears to be slower than the corrosion rate of vanadium.

A method of correcting X-ray films for linear and nonlinear shrinkage is described. Briefly, this method consists of measuring the change in position, upon processing, of a series of small holes that have been punched in the film by a calibrated film punch.

PREDICTING PERFORMANCE OF SINGLE AND MULTIPLE CROSSES FROM PERFORMANCE OF INBRED LINES OF SWINE[1]

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The primary purpose of the present investigation was to determine how accurately the performance of single crosses and multiple crosses could be predicted from knowing the performance of the inbred lines. The characteristic studied in greatest detail was 154-day weight of the individual pig, with some attention being given to total litter weight at the same age. The data used in this study came from the 12 Poland China lines maintained by the Iowa Agricultural Experiment Station in cooperation with the U.S.D.A. Regional Swine Breeding Laboratory. They were collected during the period from the fall of 1942 through the spring of 1950, and they consisted of 3541 inbred pigs and 1399 single cross pigs.

In order to study the predictive value of a line's own performance in predicting single and multiple cross performance, various correlations were calculated using both individual and litter weight at 154 days of age. Similar correlations were made to determine if single cross data would predict multiple cross performance more accurately than inbred line data. The correlation between inbred line average and average of all single crosses involving that line was 0.57. The correlation between inbred line performance and multiple cross performance was 0.50, while the same correlation between single cross and multiple cross was 0.38. The results of this study indicate that an inbred line's own performance is useful as a basis for culling the very poorest lines. For this sample of lines very little was gained from including single cross data in the prediction of multiple cross performance.

A path coefficient analysis of the source of the correlation between the average of an inbred line and the average of all single crosses involving that line indicated that epistasis contributed very little, if at all, to such a correlation.

Although a test of significance of differences between the lines for maternal effects was not made, considerable evidence was accumulated which indicated that these effects are large enough to be important. This evidence emphasizes the importance of considering mothering ability in the selection of lines and in the planning of single and multiple crosses.

The following plan is suggested as appropriate for the production of inbred lines and their crosses. (1) Start many small inbred lines up to a maximum of about twice the number that can be tested. (2) Inbreed as rapidly as possible without slowing this rate in order to increase selection pressure. (3) Cull the lines on the basis of their own performance and mothering ability to the number that can be tested. (4) Perform the test crosses and cull again on this basis.

Since the best test cross may depend upon the mode of gene action affecting the trait, a constant parent regression analysis was made to determine if the effects of overdominance were important. Although the constant parent method was developed for homozygous lines, the analysis indicated that it can be effective with lines less highly inbred if a sufficient range in gene frequencies between lines can be assumed. The

[1]Doctoral thesis no. 1478, submitted December 9, 1953. Chairmen of Committee, L.N. Hazel, Department of Animal Husbandry, and J.W. Gowen, Department of Genetics.

[2]B.S., Iowa State College, Ames, Iowa, 1948. M.S., South Dakota State College, Brookings, S.D., 1949. Instructor.

results of this analysis did not show any evidence for overdominance. However, the data are not sufficient to be conclusive on this point. All of the crosses were within the Poland China breed, and the level of heterosis was low in comparison to line crosses between breeds. Many more such analyses are needed involving different lines and lines from different breeds.

DETERMINATION OF STRESS-STRAIN CHARACTERISTICS OF MATERIALS SUBJECTED TO DYNAMIC LOADING[1]

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Research to find new materials and new designs which will permit greater use of existing materials is handicapped by a lack of understanding of how materials behave when they are subjected to dynamic loads. The special aspect of material behavior considered in this investigation was the stress-strain characteristics of the material. This investigation was confined to the determination of stress-strain characteristics in those cases for which the dynamic loading produces either simple tension or simple compression.

A method for predicting the stress-strain diagram for a material subjected to a dynamic load was developed. This method involves the concept of unrelaxed and relaxed stresses within the material as well as the concept of a material property which determines how the relaxation of stress progresses with time. Theoretical background for these concepts was presented. A general differential equation which relates stress, strain, and time was discussed in detail. This equation involves a modulus of elasticity associated with unrelaxed stresses (the unrelaxed elastic modulus), a modulus of elasticity associated with relaxed stresses (the relaxed elastic modulus), and a stress relaxation constant.

This general differential equation relating stress, strain, and time was solved for four strain-time curves.

1. Strain increases from zero to some maximum value at a constant rate and then remains constant.
2. Strain increases from zero to some maximum value at a constant rate and then decreases back to zero at the same constant rate.
3. Strain increases from zero to a maximum value so that the strain-time curve is the first 90 degrees of a sine wave. The maximum value of strain is maintained.
4. Strain increases from zero to a maximum value and then decreases to zero so that the strain-time curve is the first 180 degrees of a sine wave.

An experimental technique for evaluating the unrelaxed elastic modulus, the relaxed elastic modulus, and the relaxation constant was developed. The test equipment which was designed and constructed for the purpose of evaluating these two moduli and the relaxation constant was described in detail. This test equipment was used to evaluate the two moduli and the relaxation constant for a single type of natural rubber. The moduli and relaxation constant thus determined were substituted into two of the theoretical equations previously developed in order to predict the shape of the stress-strain curve associated with various constant rates of increasing strain and with constant rate strain cycling. The predicted stress-strain curves were compared with experimentally determined curves.

The velocity of strain wave propagation was studied experimentally to establish what, if any, relationship exists between the unrelaxed elastic modulus and the velocity of strain wave propagation. The same natural rubber was used in these wave propagation tests as was used in the constant rate of straining and strain cycling tests.

The agreement between the theoretical stress-strain curves and the experimental curves justifies the following conclusion: For the material used in these tests and within the range of strains (zero to five per cent in compression) and strain rates

[1]Doctoral thesis no. 1527, submitted May 10, 1954. Chairman of Committee, Glenn Murphy, Department of Theoretical and Applied Mechanics.

[2]B.S., Iowa State College, Ames, Iowa, 1947. M.S., Ibid., 1949.

(up to 34 per cent/second) investigated the proposed method is suitable for predicting how the rate of straining will affect the stress-strain diagram. In the author's opinion the results obtained in applying the proposed method to rubber justify study of other materials.

The experimental study on the velocity of strain wave propagation indicated that the velocity of propagation is definitely related to the unrelaxed elastic modulus. It was pointed out how wave propagation tests might be used to evaluate the unrelaxed modulus, the relaxed modulus, and the relaxation constant.

PILOT PLANT STUDIES OF QUICK-CURING OF SUPERPHOSPHATE[1]

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Pilot plant studies were carried out on the quick-curing of superphosphate made by acidulating ground Florida pebble phosphate rock with 55 per cent sulfuric acid using an acidulation of 1.81 pounds of H_2SO_4 per pound of P_2O_5.

The quick-curing operation was performed in a pilot plant Roto-Louver dryer 6 feet long and 13 inches average inside diameter. The drying air was heated in a furnace fired with natural gas. The acidulation step was carried out batch-wise and after a block of superphosphate had been formed in a den it was continuously disintegrated by a Sturtevant-type cutter mechanism. This material was continuously fed into the dryer where it was quick-cured.

The fresh superphosphate could be disintegrated and conveyed without difficulty provided no excessive pressure was exerted on the material. The time of mixing in the acidulation step greatly influenced the cutting and conveying characteristics of the raw superphosphate.

Quick-curing in the Roto-Louver dryer achieved a maximum conversion to available P_2O_5 at a relatively high moisture content. As drying progressed, the conversion decreased but the available P_2O_5 content increased to an essentially constant level. The free acid content decreased as conversion increased.

The effect of inlet air temperature on the quick-cured product composition was studied. At a given air temperature a product composition based on the maximum value of available P_2O_5 content reckoned to the lowest whole number of per cent could be determined. This maximum composition was found to vary with air temperature in a characteristic manner.

Inlet air temperatures from 400° to 1141°F were studied. For a given product moisture, the capacity of the dryer appeared to be directly proportional to the air temperature. However, the moisture content at the maximum available P_2O_5 content increased with air temperatures over 800°F, sharply raising the dryer capacity at these higher temperature levels by reducing the heat load per unit feed of the dryer.

Laboratory studies showed that the degree of hydration of superphosphates increased with decreasing sulfuric acid concentration. Most of this hydration was attributed to the calcium sulfate formed by the reaction of sulfuric acid with phosphate rock. The amount of hydration present in fresh and storage-cured superphosphates had a marked effect on their physical properties. Though some of the storage-cured superphosphates had moisture contents as high as 14 per cent, they appeared to be as dry as some superphosphates of only 3 per cent moisture content.

The choice of the optimum operating conditions involves an economic balance between the factors of decreased production costs at higher air temperatures and increased conversion at lower air temperatures. The economic feasibility of the process for quick-curing of superphosphate appears promising.

[1]Doctoral thesis no. 1485, submitted December 12, 1953. Chairman of Committee, G. L. Bridger, Department of Chemical and Mining Engineering.

[2]B.Sc. Drexel Institute of Technology, Philadelphia, Penn., 1944. M.Sc., Kansas State College, Manhattan, Kansas. 1950. Graduate Assistant, Engineering Experiment Station.

INTERRELATIONS OF PLANT POPULATIONS, FERTILITY LEVELS AND HYBRIDS IN CORN PRODUCTION[1]

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Influences of soil fertility and plant population levels on selected corn hybrids of different maturity ratings were studied at four widely separated locations with different soil types and levels of past management in 1952. Two fertility levels, five plant population levels and three hybrids were combined in a split-split plot design with six replications at each location. The growing season was favorable at all locations.

Corn grain yields were increased by an application of commercial fertilizer, assumed to be adequate, at all locations. The degree of response to applied fertilizer was determined by the plant population, the initial fertility level of the soil and to a lesser extent by the hybrids. Yield increases attributable to applied fertilizer ranged from 7.5 bushels to 101.9 bushels per acre.

Yields were increased at all locations by increasing plant populations upward from the 8,000 per acre level under conditions of high fertility. Yields were unchanged or decreased by increasing plant population levels under conditions of low soil fertility. Yield differences attributable to increasing plant populations from 8,000 to 24,000 plants per acre ranged from a decrease of 22.7 bushels per acre at the lowest fertility level to an increase of 64.8 bushels on the high fertility level.

The late hybrid usually outyielded the adapted and early hybrids at comparable populations, up to 16,000 plants per acre on the high fertility level. At the low fertility level the tendency was the same, but was less marked and not consistent. At the lowest level the late hybrid yielded more than the adapted and early hybrids, but did so in only one case at the highest population level.

Plant population and soil fertility differences also affected plant characteristics.

Maturity of all hybrids was advanced by the addition of commercial fertilizer to soild with low initial fertility. Maturity was not consistently altered by additions of fertilizer to soils of moderate initial fertility. Increasing plant populations at less than adequaté fertility levels delayed maturity.

Per cent of barren plants increased sharply on low fertility soils as populations were increased above 12,000 plants per acre. It was also increased, but more slowly, above the 16,000 plant level when soil fertility was high.

Ear height was increased by the addition of commercial fertilizer on all hybrids at all locations. The increase was greater at high than at low plant population levels. There was little influence on ear height at different plant populations on the low fertility level.

Plant height was increased by the addition of commercial fertilizer at all population levels, but the increase was more evident at the higher levels. At low fertility levels plant height was not appreciably influenced by changes in plant population levels.

Stalk lodging was not consistently influenced by changes in fertility level. It was erratically greater as plant populations were increased above the 8,000 plant per acre level.

Multiple ear plants were not observed on moderate and low fertility levels, but were observed up to the 16,000 population level when commercial fertilizer was added.

Tillering was evident at only one of the four fields and there only at the low population and high fertility level.

Weight of stover was increased by added commercial fertilizer and by increasing plant populations at all fertility levels. Stover weight of the late hybrid was greatest and was lowest for the early hybrid at comparable fertility and plant population levels.

Differences in plant population and soil fertility level also influenced ear characteristics of hybrids at all locations.

Mean ear weight was increased at any population level by the addition of commercial fertilizer. It was decreased at both fertility levels as populations were increased from the 8,000 to the 24,000 plant per acre level. Ear weight of the early hybrid was less than those of the adapted and late hybrids at low population and high fertility levels.

[1]Doctoral thesis no. 1517, submitted March 14, 1954. Chairman of Committee, I. J. Johnson, Department of Agronomy.

[2]B.S., Iowa State College, Ames, Iowa, 1939. M.S., Ibid., 1943. Assistant Professor.

There was no apparent difference in ear weight between hybrids at high population and low fertility levels. Maximum yields on low fertility levels were made with 0.3 to 0.4 pound ears and on high fertility levels with 0.4 to 0.5 pound ears.

Mean ear diameter was decreased on low fertility levels and to a lesser degree at high fertility levels as plant populations were increased above 8,000 plants per acre. Ear diameter was increased by use of commercial fertilizer only at the field with the lowest initial fertility.

Ear length was increased by using fertilizer; greater increases occurred on fields with low initial fertility level. It was decreased as population levels were increased at both fertility levels.

Shelling percentage was decreased at low fertility levels when plant populations were increased. The greatest decrease occurred at the lowest initial fertility levels. Shelling percentage tended to be greater on the high fertility level as plant populations were increased from 8,000 to some higher level.

Observations were made and readings taken on evidence of corn borer attack, light penetration at different locations with respect to the corn plant, and on weed growth at all locations. Chemical leaf analyses also were made. Since these were supplemental observations and were made to facilitate interpretation of pertinent data, no conclusions were drawn. Readings also were taken on dropped ears, root lodging, smut incidence and army worm damage, but no readings averaged as much as one per cent and the data are not reported.

This study has emphasized the need for continued investigations by showing the possibilities of studying interrelationships in corn production practices. Partly as a result of this study, several new types of experiments are already underway and methods have been modified in other experiments to take advantage of certain of the findings in the present study.

A THEORETICAL STUDY OF THE ELECTRONIC STRUCTURE OF WATER[1]

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The molecular orbital (MO) approximation is one of the important methods which is utilized for dealing with problems of molecular electronic structure. It represents the natural extension of well-known atomic concepts to the molecular domain. In practice, the MO approach has found a large degree of success on qualitative and semi-empirical grounds. Recently, C.C.J. Roothaan (1) has outlined a rigorous, yet straightforward, mathematical formulation of self-consistent field (SCF) MO theory, into which he has incorporated the linear-combination-of-atomic-orbitals (LCAO) approximation. The SCF method secures the best possible wave function for a molecule within the scope of the MO treatment. The availability of such a systematic approach has encouraged application to a variety of molecules, but it can hardly be said that the limitations have been sufficiently determined. The main objective of the present research has been to determine the ten-electron LCAO SCF MO wave function for the H_2O molecule.

Results are reported for the experimentally observed O-H distance of 0.958 angstroms, and for six values of the H-O-H bond angle: 90, 100, 105, 110, 120 and 130 degrees. Orthogonalized Slater orbitals with the usual Slater effective nuclear charges were used. Two calculations were performed for each bond angle: a complete treatment which permitted full 1s-2s-2p mixing; and, approximate treatment which contained the conventional approximation of replacing the molecular innermost shell by an oxygen 1s Slater orbital, and allowing no 1s mixing in the outer shells. The MO's of the latter calculation are not completely orthogonal as they are in the former.

All integrals involved in the calculations were computed to four- and five-place accuracy with the exception of two small two-center exchange integrals, four of the five three-center nuclear field attraction integrals, and the remaining three-center

[1]Doctoral thesis no. 1446, submitted July 17, 1953. Chairman of Committee, Harrison Shull, Department of Chemistry.

[2]B.S., Creighton University, Omaha, Nebraska, 1949. Jr. Chemist. Research Assistant, Institute for Atomic Research.

electronic repulsion integrals. Individual study of all approximated terms was carried out by the usual as well as by new methods in order to insure reliable values.

The LCAO MO's were found to be in relatively good agreement with qualitative considerations of the electronic structure of H_2O as well as with the results of semi-empirical methods. The computed ionization potentials agreed with experiment within +1.3 electron volts (approximately 10 per cent), the order of their assignment being determined quite conclusively. Significant differences between the approximate and complete treatments were found both for the MO's and ionization potentials.

The calculated total molecular energy was found to have a minimum for an H-O-H bond angle somewhat greater than 120 degrees. Possible explanations for this disagreement with the observed 105 degree equilibrium bond angle are discussed. The effect of error in the approximated three-center integrals was found to be of significance with respect to the total energy calculation.

The wave function computed according to the complete treatment yielded a dipole moment of 1.5 D, which is in good agreement with the observed 1.84 D. The dipole is directed in the sense $H_2^+O^-$.

Configuration interaction using SCF excited orbitals was found to be unimportant with respect to the MO ground state wave function. Calculations of excitation frequencies and electronic transition probabilities indicated, however, that the LACO forms for the excited MO's should contain higher energy AO's.

The SCF calculations are supplemented by a rather extensive survey of the previous theoretical studies of H_2O. Numerical applications of the Principle of Maximum Overlap (2,3) and Mulliken's magic formula (4) are carried out. It is concluded that the former principle should be maintained only as a most qualitative idea, since molecule formation can be regarded as a competition between many factors of comparable importance, only one of which is the procurement of large bond overlap.

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FLORAL INDUCTION IN SOJA MAX[1]

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Lincoln soybeans behave as short day plants in their photoperiodic responses when young but become indeterminate in their flowering responses with increased maturity. The commencement of flowering on an 18 hour day is more closely related to plant maturity, as measured by the ratio of the mature to immature leaf areas, than to age alone. Also, nicotine sulfate induces earlier flowering of plants on 18 hour days.

These observations led to a study of the relationship of the degree of maturity to the commencement of flowering at four photoperiods, 11.5, 13.0, 14.5, and 16 hours, for the varieties Lincoln and Ogden. The effects of indoleacetic acid (IAA), IAA plus nicotine sulfate, nicotine sulfate, and 2,4,6-trichlorophenoxyacetic acid (2,4,6-T) in conjunction with the above photoperiods were also studied.

Lincoln soybeans flowered on all photoperiods except when treated with 2,4,6-T. However, the Ogden variety flowered on 16-hour photoperiods only when treated with nicotine sulfate. Treatments involving nicotine sulfate induced earlier flowering, flowering at lower nodes, and more flowers per flowering node with each variety. Nicotine sulfate induced formative effects on the young leaves which indicated an anti-auxin activity. Vein development was retarded while intervein tissue developed almost

[1]Doctoral thesis no. 1433, submitted July 14, 1953. Chairman of Committee, W. E. Loomis, Department of Botany and Plant Pathology.

[2]B.S.A., University of Toronto, Canada, 1950. M.S., Iowa State College, Ames, Iowa, 1952. Graduate Assistant, Agricultural Experiment Station.

normally, giving a crinkled appearance to the leaves. Internodes did not expand to the length noted for the checks.

For each photoperiod a distinct ratio of mature to immature leaf areas was reached before flowering commenced. The smallest ratios were found for plants on the shortest photoperiods while the largest ratios were found for plants on the longest photoperiods. The Ogden variety, which flowered later than the Lincoln, reached a larger ratio than the Lincoln variety before flowering commenced. The ratio was smaller for all treatments involving nicotine sulfate than for the checks, treatments involving IAA alone, or 2,4,6-T.

Since the young leaves are known to be auxin producers and the mature leaves are apparently flowering mechanism producers, the ratio of mature to immature leaf areas is assumed to be an indication of the ratio of the flowering mechanism producing tissues to the auxin producing tissues. An antagonism between the auxins produced in the young tissues and the flowering mechanism produced in the mature leaves is postulated. Nicotine sulfate acting as an anti-auxin would then reduce the auxins to a level where the antagonistic reaction would no longer be severe enough to prevent flowering.

In order to test this hypothesis further, mature leaves, apical meristems or immature leaves were removed from Lincoln soybeans growing on an 18 hour photoperiod, at various stages of maturity. Removing two or more mature leaves delayed flowering, complete detopping almost prevented flowering, while removing immature leaves when 4, 5 or 6 trifoliate leaves were mature induced earlier flowering, flowering at lower nodes, and more flowers per flowering node than other treatments. Thus the removal of a portion of the auxin producing tissue induced earlier flowering but the total removal forced the rapid development of auxin-producing axillary shoots.

Nicotine sulfate was applied to localized portions of Lincoln soybeans on 18-hour photoperiods. When applied to the immature leaves when 4 or 5 trifoliate leaves were mature, plants flowered earlier, at lower nodes, and with more flowers per node than when only mature leaves were treated. Also, the ratio of mature to immature leaf areas was smaller at commencement of flowering. Spraying the whole plant was not more effective in inducing earlier flowering than treating only the young leaves.

Since nicotine sulfate induced earlier flowering and appeared to be an anti-auxin in its biological activity, an attempt was made to counteract the anti-auxin activity with applied auxins. Plants treated first with nicotine sulfate were treated for 28 days thereafter with either indoleacetic (IAA) or indolebutyric acid (IBA) at concentrations from 10 to 1,000 ppm for IAA, or 10 to 200 ppm for IBA. Flowering in every treatment was delayed beyond the untreated checks. The latest flowering plants were those receiving the highest concentrations of auxin.

The action of nicotine sulfate was compared with 2,3,5-triiodobenzoic acid, a recognized anti-auxin, and with maleic hydrazide, and anti-metabolite, to determine more precisely the role of nicotine sulfate on the flowering responses of Lincoln soybeans. Nicotine sulfate and TIBA induced similar symptoms of anti-auxin activity on Lincoln soybeans on 20-hour photoperiods. Flowering was earlier and more profuse than for check plants. Maleic hydrazide stimulated axillary growth, but flowering was markedly delayed.

A balance between the auxins and the flower producing mechanism appears to exist. This balance can be shifted in the direction of flower production by (a) applying anti-auxins, or (b) removing immature (auxin-producing) leaves. The ratio of mature to immature leaf areas at commencement of flowering serves as rough measurement of the balance.

HEATS OF SOLUTION AND RELATED THERMOCHEMICAL PROPERTIES OF SOME RARE EARTH METALS AND CHLORIDES[1]

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Department of Chemistry

An isothermally jacketed calorimeter has been constructed to measure the changes in heat content accompanying the solution of some rare earth metals and compounds. To check the performance of the apparatus, the integral heats of solution of potassium nitrate in water at 25°C have been measured. The values corrected to infinite dilution by use of relative apparent molal heat content data in the literature give 8384 ± 12 cals/mole. The result agrees well with the values reported by others.

The integral heats of solution in water of the anhydrous chlorides of lanthanum, praseodymium, samarium, gadolinium, erbium, ytterbium, and yttrium, have been measured at 25°C. For each salt, empirical equations of the general form

$$Q_M = a + bm^{\frac{1}{2}} + cm$$

have been formulated to represent the experimental data in the concentration range studied. The constant, b, has been taken as the theoretical limiting slope given by the Debye-Huckel theory. The values of the constants, a and c, are given in a table. A plot of the constant, a, which is the heat of solution at infinite dilution, gives a smooth curve for the chlorides from lanthanum through gadolinium. That erbium and ytterbium do not form part of the smooth curve is explained on the basis of the change in crystal structure from hexagonal to monoclinic. The value for yttrium chloride falls between gadolinium and erbium.

The integral heats of solution of the metals and anhydrous chlorides of yttrium, lanthanum, praseodymium, gadolinium, and erbium, have been measured in hydrochloric acid solutions at 25°C. These data have been used to calculate the standard heats of formation of the anhydrous chlorides and aqueous rare earth ions.

The integral heats of solution of the hydrated chlorides of yttrium, lanthanum, praseodymium, samarium, gadolinium, erbium, and ytterbium, have been measured in water at 25°C. These data, together with the heats of solution of the anhydrous chlorides in water, have been used to calculate the heats of hydration.

The standard heats of formation of the hydrated chlorides of yttrium, lanthanum, praseodymium, gadolinium, and erbium, have been calculated from the data on the heats of hydration and heats of formation of the anhydrous chlorides.

From estimates of the entropies of the elements and compounds, the standard entropies of formation of the anhydrous and hydrated chlorides of ytterium, lanthanum, praseodymium, gadolinium, and erbium, have been approximated. Using the standard entropies and heats of formation, the standard free energies of formation of the same compounds have been calculated.

[1]Doctoral thesis no. 1442, submitted July 16, 1953. Chairman of Committee, Frank H. Spedding, Department of Chemistry.

[2]B.S., Bucknell University, Lewisburg, Pennsylvania, 1948. Jr. Chemist. Research Assistant, Institute for Atomic Research.

ZERO-SEQUENCE IMPEDANCE OF A THREE-PHASE TRANSMISSION LINE WITH GROUND RETURN[1]

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Department of Electrical Engineering

This thesis is a zero-sequence impedance determination obtained by calculation of the flux linkages and power losses established by the current flow in the earth beneath a three-phase transmission line with ground return. While the results obtained did not lead to a method of calculating impedance which is easily applied to all problems, they did confirm the results obtained by applying Carson's equations to the same transmission line.

Numerical solutions were obtained for the current density in the earth beneath each of three different three-phase transmission lines 20 meters high with equal horizontal conductor spacings of 10, 20, and 40 meters, and an earth conductivity of 0.01 mhos/meter. The results of these solutions were plotted as the current density versus horizontal distance from the center of the transmission line for various values of vertical distance below the surface of the earth. The results for the ten-meter spacing were augmented by additional curves. Although Rudenberg obtained a current density with a lagging phase angle near the transmission line, the results of this thesis indicate a leading phase angle, that is, the imaginary component of current density in the earth leads the real component.

The effective resistance of the earth was calculated by numerically integrating the i^2R losses in the earth under the line with the ten-meter spacing. The value obtained was identical with that calculated by other methods.

The effective reactance of the earth was calculated by numerically integrating the flux linkages in the earth. The value obtained was about two per cent lower than that calculated by other methods.

[1]Doctoral thesis no. 1550, submitted June 4, 1954. Chairman of Committee, W.B. Boast, Department of Electrical Engineering.

[2]B.S., University of Texas, Austin, Texas, 1940. M.S., Ibid., 1940. Instructor.

MANUFACTURING COSTS IN WHOLE-MILK CREAMERIES[1]

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As part of a broad project designed to determine effective methods of marketing milk produced on Iowa farms, this study has examined the costs of manufacturing butter in Iowa creameries receiving whole milk. This analysis was undertaken as a result of increased interest on the part of dairy farmers in the possible advantages of sending whole milk to the creamery rather than separating the milk on the farm and sending the cream to the creamery.

Cost data were obtained from an intensive study of ten whole-milk plants in Iowa, and were coupled with pertinent data obtained in 13 gathered-cream creameries used as sample plants for Research Bulletin 389 of the Iowa Agricultural Experiment Station. From these data four plants were developed on paper, producing 500,000; 1,000,000; 1,500,000; and 2,000,000 pounds of butter per year, respectively. These plants took in whole milk and separated it, processing the cream into bulk butter ready for shipment, and cooling and storing the skim milk for sale or further processing.

The total costs of these operations in the four plants were found to be 9.42, 7.18, 6.26, and 5.62 cents per pound of butter manufactured, respectively. These unit costs

[1] Doctoral thesis no. 1551, submitted June 4, 1954. Chairmen of Committee, James P. McKean, Department of General Engineering, and Geoffrey Shepherd, Department of Economics and Sociology.

[2] B.M.E., Clarkson College, Potsdam, New York, 1945. M.S., Iowa State College, Ames, Iowa, 1950. Assistant Professor. Cooperator, Agricultural Experiment Station.

decrease at a decreasing rate throughout this volume range. Costs at an annual volume of 2,000,000 pounds are the lowest, and are approximately 1.5 cents per pound lower than costs at an annual volume of 1,000,000 pounds. These costs do not include the costs of assembling the milk from the farm to the plant, however, and these assembly costs may tend to be lower in the smaller plants.

In a comparison of whole-milk operations with gathered-cream operations, the whole-milk plants have an extra product in the form of skim milk. The value of this skim milk must bear any extra costs of manufacturing and hauling involved in processing whole milk. The extra costs of manufacturing can be determined through comparison of costs developed here with those previously developed for gathered-cream creameries in Bulletin 389. The costs developed in this study were calculated in cents per pound of butter manufactured in order to permit easy comparison.

At an annual production of 2,000,000 pounds of butter, the extra costs in the whole-milk plants as compared with the gathered-cream plants amount to approximately two cents per pound of butter, while at an annual production of 1,000,000 pounds of butter, the extra costs are approximately three cents per pound of butter. A cost difference between gathered-cream and whole-milk operations of three cents per pound of butter manufactured is equivalent to a cost of 14.22 cents per pounds hundred of skim milk. The skim milk must be of sufficient value to absorb these costs if shipping whole milk to the creamery is to be considered a more desirable method of marketing the milk than separating the milk at the farm and shipping the cream to the creamery.

MONOGRAPH OF THE CYDNIDAE OF THE WESTERN HEMISPHERE[1]

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The insects comprising the family Cydnidae (exclusive of the Thyreocoridae) are a superficially homogeneous group belonging to the pentatomoid section of the order Hemiptera. The very fragmentary knowledge of their biology indicates that the great majority of them burrow in the ground where they feed on the roots of plants. This habit has earned for them the familiar appellation of "burrower bugs." A few forms are known to feed on plant parts above the ground. At present the group is not considered one of great economic importance, although several of them have been reported as damaging the roots of sugar cane, garden crops and coffee in the tropics. As knowledge of soil insects increases, these may be found to have much greater economic importance than had formerly been attributed to them.

The most recent attempt at a taxonomic revision of this group was made by Signoret in a series of papers in the Annales de la Société Entomologique de France during the years from 1881 to 1884. That study has proven very inaccurate and incomplete, and has resulted in general confusion in the identification of members of this family. It was to relieve this condition that the present author elected to attempt a revisionary study of the Cydnidae of the Western Hemisphere.

Through the generous cooperation of numerous private collectors and the curators of many museums, some 12,000 specimens (including many of the types of Signoret, Stal, Horvath, and Jensen-Haarup) were available for study. These specimens, coupled with data supplied by curators at the institutions which house the types of Uhler, Dallas, and Distant, permitted placement of most of the 146 previously described species.

As might be expected, several of the earlier names have been found to be synonyms of some of the common species. For instance, one common North American species now has eight synonyms. In addition, 43 new species were found, resulting in 159 valid species for the Western Hemisphere. Although the gonostyli were useful in specific separations, usually both sexes showed sufficient external features to limit each species. Many of these external features as well as the gonostyli are illustrated on nine plates.

[1]Doctoral thesis no. 1516, submitted March 13, 1954. Chairman of Committee, H. H. Knight, Department of Zoology and Entomology.

[2]B.S., University of Missouri, Columbia, Mo., 1941. M.S., Iowa State College, Ames, Iowa, 1951. Instructor.

Before proper systematic arrangement of the species was possible, it was necessary to review the generic and supergeneric classification of the family from world-wide approach. This resulted in marked changes of the subfamily and generic classification. Where formerly but two subfamilies were recognized, five were indicated by evidence at hand. One of these was wholly neogeic, one exclusively gerontogeic and the others occurring in both hemispheres.

The generic classification was likewise found to be very unsatisfactory. Many of the monobasic genera had been proposed on features of no more than specific worth and so could not be retained. At the other extreme, certain of the older genera had never been properly delimited and their bounds had gradually extended to engulf several distinct genera. These large genera included species from all regions of the world and so had very little zoogeographic significance. Results of the present study showed that all genera studied had limited ranges with zoogeographic significance. The Eastern and Western Hemisphere, in spite of extensive literature to the contrary, were found to have but one genus in common, a Palearctic one with but a single, widespread species in North America. While some 36 generic names have been involved in the literature of the New World Cydnidae, the present study recognizes only fifteen full genera and three subgenera as members of this fauna. Since most of these are restricted to the New World, the present study amounts to a preliminary generic revision, with a habitus illustration of the genotype of each.

The older classifications were found to have relied too much on the vestiture of the head and thorax and the labial length for higher categories. Use of the fine abdominal hairs known as trichobothria and the wing venation indicated five subfamily divisions which were found to be supported by additional, more easily ascertained modifications of other parts of the body and appendages.

At the generic level the presence or lack of modifications of the osteolar peritreme, as first used by Uhler, proved to be very valuable. Where modifications were present, they were of sufficient variation to serve as the bases for delimiting genera. Where these modifications were absent, characters had to be drawn from other parts of the body. While the resulting generic classification is in the main distinct and easily used, there still remains a heterogeneous lot of species which are lumped into two poorly separated genera. Apparently, this area needs more intensive investigation to discover features which will permit establishment of smaller, more easily defined genera.

Since the previous classification of the Cydnidae resulted in such muddled, unreliable determinations of specimens, reference to earlier literature was confined to that including descriptions of new forms, major attempts at revisionary studies and catalogues and to important biological contributions. Until the present studies have been reinforced and concluded by the discovery of certain critical type specimens of earlier authors, the inclusion of a complete catalogue of all literature on the Cydnidae of the New World is not feasible.

FEEDBACK AND STABILITY OF JUNCTION TRANSISTOR CIRCUITS[1]

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At the present time, little is known of the effects of feedback in transistor circuits. Circuits utilizing feedback techniques have only begun to appear. Presently known methods of circuit analysis are not always adequate for use in analyzing these circuits. In all, considerable development is needed in this field.

The material presented in this theses is directly concerned with the study of feedback and stability in junction transistor circuits. All discussion is limited to the small signal or linear operation of transistors and to those frequencies which permit the equivalent circuit parameters to be nonreactive. Emphasis is placed on circuit analysis beginning with the selection of usable equivalent circuits and ending with the method of

[1]Doctoral thesis no. 1468, submitted December 3, 1953. Chairman of Committee, W. L. Cassell, Department of Electrical Engineering.

[2]B.S., Iowa State College, Ames, Iowa, 1945. M.S., University of Nebraska, Lincoln, Nebr., 1948. Assistant Professor.

handling cascaded circuits with feedback. Feedback circuits are developed and broadly classified. The effects of feedback on single stage circuits are extensively analyzed.

In this research, three transistor connections are considered: grounded base, grounded emitter, and grounded collector. It is found that for each of these connections, two equivalent circuits are particularly useful: a mesh-derived equivalent circuit taking the form of a T and a nodal-derived equivalent circuit taking the form of a π. The T equivalent circuits corresponding to the three connections differ only in the value of the equivalent circuit parameters. The same is true for the π equivalent circuits. To simplify the notation and to reduce the number of parameters, the parameters of all equivalent circuits are written in terms of r_e, r_b, r_c, and r_m which are the parameters for the well known mesh-derived grounded base equivalent circuit.

The network coefficients pertaining to the nodal equations of eight P-N-P junction transistors were measured. At present, existing equipment can be used to measure these network coefficients most easily. The transistors were connected as grounded emitter although either of the other two connections would have been permissible. From these measurements, the equivalent circuit parameters of all the useful equivalent circuits are easily evaluated.

Single stage circuits utilizing feedback techniques are investigated. It is found that the trsnsistor is inherently a feedback device due to the presence of the shunt element in the T or π equivalent circuits. Furthermore, it is found that feedback can be controlled by the addition of circuit elements which modify the value of these shunt elements. The addition of circuit elements (including transformers) which directly modify the shunt element of the T equivalent circuit, termed "series added feedback," are handled separately from the addition of circuit elements which directly modify the shunt element of the π equivalent circuits termed "parallel added feedback." In cases where both series and parallel feedback are involved, a method is used to convert the parallel feedback to series feedback or series feedback to parallel feedback, whichever is most desirable. Several useful series and parallel feedback circuits are illustrated and analyzed.

To analyze the single stage feedback circuits, two sets of general equations are derived: one set for T equivalent circuits and one set for π equivalent circuits. Each set is written in terms of the network coefficients and is applicable to each of the three connections studied. In each set are equations for input impedance, output impedance, voltage gain, current gain, power gain, return difference, sensitivity and the instability condition. The form taken by these equations when the transistor is terminated in its image impedance is also given. It is found that the series feedback circuits are most easily handled by the equations pertaining to the T equivalent circuits, while parallel feedback circuits are most easily handled by the equations pertaining to the π equivalent circuits. Analysis of both series and parallel feedback circuits for all three connections shows that matched input impedance, matched output impedance, power gain, return difference and stability are very much dependent upon feedback and can be controlled through use of feedback techniques.

Cascaded transistor circuits are found to present no great problem when a method termed "circuit reduction of active networks" is used. This method consists of reducing a cascaded circuit of any number of stages to one four-parameter equivalent circuit. This composite equivalent circuit (T or π) is identical to the T or π equivalent circuits used for the previous single stages. No restriction is placed upon the equivalent circuit representation of each individual transistor.

When feedback is added to the cascaded circuits, it is found that circuit reduction can still be applied in most cases. The feedback considered may be of either the series or the parallel form, involving any number of stages. Of most significance, after the cascaded circuit has been reduced, the general circuit equations derived for single stage circuits still apply.

ACTION OF HERBICIDES ON WOODY PLANTS[1]

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In recent years there has been a great deal of interest in chemical brush control. This interest has been due in part to the discovery of growth regulator chemicals such as 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), which have made brush control economical on large areas where formerly it was considered uneconomical or impossible. A continued interest in brush control is emphasized by the increasing use of 2,4,5-T, which is used primarily for control of woody plants, while the use of 2,4-D has remained constant.

Applications of herbicides were made to elm (Ulmus americana and U. fulva), oak (Quercus macrocarpa and Q. borealis), honey locust (Gleditsia tricanthos) and hickory (Carya ovata) by injection into notches on the stem. Elm, oak, hickory, cherry (Prunus serotina), box elder (Acer negundo) and buckthorn (Rhamnus spp.) were treated by spraying herbicide solutions on the basal portion of the stem, here referred to as the basal stem method. Foliar applications of herbicides were made to buckbrush (Symphoricarpos orbiculatus). Excised, dormant twigs of willow (Salix amygdoloides) were treated at various positions and with various concentrations of herbicides to investigate the response of dormant buds to herbicides. Multiflora rose (Rosa multiflora) was treated with hormone herbicides in an attempt to measure translocations under different conditions. Applications to elm stumps were made to corroborate the results of the basal stem treatments. Individual plants were used as the experimental unit with all methods except the foliage spray method, where square rod plots were used.

Basal stem applications of herbicides were most effective when applied in late May at the full-leaf stage of development. Higher concentrations and higher rates of application were more effective than lower concentrations or rates. Basal stem applications gave better control than soil applications, and 2,4,5-T esters produced more cambium and root kill than 2,4-D esters. Para-chlorophenyl-1, 1'-dimethyl urea (CMU) was toxic to elm but the results were incomplete. Basal stem treatments affected all species treated. Stump applications were effective and the results were similar to basal stem applications.

Injection applications were more effective during the full-leaf stage of growth, affected all species treated, and showed promise of being an economical method of controlling woody plants. Amine formulations gave better control then esters. 2-Methyl, 4-chlorophenoxyacetic acid (MCP) and 2,4,5-T formulations were generally inferior to 2,4-D, and applications near the ground were more effective than those higher.

Foliage applications using water as a carrier were more effective than those using other diluents. The addition of a wetting agent increased the effect of both amine and ester treatments. Without a wetting agent, ester formulations were consistently better than amine. Ammonium sulfamate was effective only at higher rates; 2,4-D formulations gave better control of buckbrush than 2,4,5-T, and MCP formulations were consistently inferior to 2,4-D.

Excised willow twig experiments showed that there was a response to varying concentrations of herbicides. Basal applications were more effective than apical and showed more translocation. Growth of apparently normal buds was inhibited by 2,4-D and 2,4,5-T.

Multiflora rose as a test plant for translocation experiments gave such variable results that no differences could be measured.

[1]Doctoral thesis no. 1438, submitted July 15, 1953. Chairman of Committee, W. E. Loomis, Department of Botany and Plant Pathology.

[2]B.S., Iowa State College, Ames, Iowa, 1950. M.S., Agricultural and Mechanical College of Texas, State College, Texas, 1951. Graduate Assistant, Agricultural Experiment Station.

MOLECULAR ORBITAL TREATMENT OF SUBSTITUTED BENZENE SPECTRA[1]

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It is shown in this study how the conventional naive semi-empirical molecular orbital approach for conjugated hydrocarbons may be complemented by means of theoretically computed electron repulsion integrals in a manner suggested by the more rigorously founded SCF procedure. This is shown to give satisfying results in three examples, with a considerable reduction in labor as compared to the complete ASMO method. The method is carried over in a natural and simple manner to substituted hydrocarbons, providing unambiguous methods of evaluating empirical resonance and inductive parameters. The concept of "weak" and "strong" substituent is developed, and it is shown how these provide simple intuitive approaches to the estimation of interaction parameters in the theory. The inductive and resonance effects upon the energy levels are shown to be far from additive, and indeed are dependent upon each other. The dependence is analyzed, and it is indicated which ones are important (and determinable) from various experimental situations.

The modified semi-empirical method is applied to the general problem of the prediction of spectra of substituted conjugating hydrocarbons. It is shown that the new method has many of the advantages of the more rigorous ASMO approach in, for example, distinguishing between states of different multiplicity, without the attendant disadvantages of overly lengthy computation, too large singlet-triplet separations, and the like. The case of limited configuration interaction arising from degenerate or near-degenerate levels in the parent hydrocarbon is discussed in detail from the viewpoint of "strong" and "weak" substituents. It is shown that this is a factor of major importance in molecules to which it is applicable and that a consideration of its effect can be used for the assignment of transitions. A method is suggested in which empirical parameters determined from π-π spectra can be used in the prediction of n-π spectra. Brief attention is given to the problem of polysubstitution, and to the calculation of delocalization energies and π-electron moments.

The procedure is then applied to substituted benzenes. Several of the derived conclusions are verified for these compounds. Empirical parameters are evaluated for a series of substituents from the long wavelength transition and ionization potential.

[1]Doctoral thesis no. 1521, submitted April 7, 1954. Chairman of Committee, Harrison Shull, Department of Chemistry.

[2]B.A., New York University, New York City, 1948. M.S., Cornell University, Ithaca, N.Y. 1950. Jr. Chemist. Research Assistant, Institute for Atomic Research.

SELECTIVE CHEMICAL ANTAGONISM OF LACTIC STREPTOCOCCUS BACTERIOPHAGE[1]

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Discovery of an effective inhibitor of lactic streptococcus bacteriophage (bacterial virus) would have a definite practical application in the cheese and cultured milk industries. In addition, present knowledge indicates that selective chemical inhibition is the only method by which the processes leading to virus synthesis can be divorced from the normal host metabolism sufficiently to permit mechanistic studies of virus multiplication. The influence of various agents and the mode of action of crystal violet in retarding the development of bacteriophage were studied in this work.

Experiments were carried out in two media, differing in the level of definition.

[1]Doctoral thesis no. 1505, submitted January 25, 1954. Chairman of Committee, F. E. Nelson, Department of Dairy Industry.

[2]B.S., Mississippi State College, State College, Miss., 1950. M.S., Iowa State College, Ames, Iowa, 1951. Research Associate, Agricultural Experiment Station.

Results obtained in trypticase soy broth (Baltimore Biological Laboratories) were confirmed in a partially chemically defined medium. A paper-disc, agar-diffusion method was employed for primary screening, and quantitative methods were employed for confirmatory investigation. These methods were designed for the study of such characteristics of virus growth as viability of particles (virucidal effects), attachment to host cells (adsorption), penetration of host cells (invasion), rate of multiplication (latent period and virus yield), release of virus (rise period), extent of proliferation (burst size) and destruction of host bacteria (mass lysis). The influence of inhibitors on the rate of multiplication of host cells also was studied.

Ninety-nine selected compounds and eleven antibiotic-producing organisms were tested for antiphage activity and host toxicity. Most of the agents tested, although previously reported as selectively inhibitory to the virus in one or more other virus-host systems, did not prevent multiplication of lactic streptococcus bacteriophage. Several compounds which retarded virus development were extremely toxic to the host bacteria. Many other toxic agents did not influence directly the proliferation of bacteriophage.

Crystal violet suppressed growth of two bacteriophage strains at very low levels (1.0×10^{-7} M) which permitted normal multiplication of the host cells. Failure of crystal violet selectively to prevent development of many bacteriophage strains suggested possible variations in the multiplication mechanism of different viruses. Strains of host bacteria selected from large populations by means of resistance to relatively high levels of crystal violet did not differ from the original type in the level of dye required to inhibit virus growth on the different strains. Virustatic levels of crystal violet did not destroy unadsorbed virus, reduce adsorption or prevent invasion; increase of virus was reduced in one-step growth experiments; mass lysis was prevented or delayed in long-time experiments. Addition and removal of crystal violet at various intervals during the latent period resulted in virus yields directly related to the portion of the latent period during which no dye was present. Removal of crystal violet following its presence during most of the latent period resulted in a slight delay in the release of virus. Burst size experiments indicated that the yield of plaque-forming particles per infected bacterium was reduced; the proportion of infected bacteria giving rise to active progeny did not appear to be influenced to a significant degree. The evidence indicates that crystal violet interferes with a late phase of intracellular multiplication of the virus.

Inhibition of virus by crystal violet was not counteracted by yeast extract, reticulogen (liver extract), hydrolysed casein, tryptophan or sodium thioglycolate. Crystal violet was antagonized by desoxyribose nucleic adid (DNA) but not by ribose nucleic acid in vivo; precipitation of DNA by crystal violet was demonstrated in vitro. The constituent purine and pyrimidine bases of DNA (adenine, guanine, cytosine, and thymine), as well as D-ribose, did not overcome the inhibitory effect of crystal violet. Analogs of folic acid, purines, pyrimidines and one nucleoside analog did not prevent virus multiplication. The data indicate that inhibition of bacteriophage by crystal violet may result from combination of the dye with virus DNA at some critical stage in the incorporation of DNA into the virus particle.

Only a small proportion of the bacteriophage strains tested were inhibited selectively, and the inhibition ratios were rather narrow in these cases. These facts make crystal violet unsuitable as a bacteriophage inhibitor in commercial dairy fermentations.

CATALYTIC OXIDATION OF PROPANE[1]

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The production of alcohols, aldehydes, ketones, and acids by the oxidation of propane is possible and economically attractive, with raw materials representing only two to twenty per cent of the product selling price. Commercial noncatalytic processes now produce mixtures of these products which are difficult to separate and purify.

The high temperature catalytic oxidation of propane by oxygen was studied in a simulated fluidized bed at atmospheric pressures with no recirculation of catalyst. This process was developed in an attempt to provide the temperature control and the promotion of a specific reaction which are necessary to yield given oxygenated chemicals from oxygen and propane.

The experimental equipment provided for mixing heated, measured amounts of oxygen and propane in the presence of catalyst at various temperatures and flow rates. A mechanically-agitated bed of catalyst was used to simulate a conventional fluidized bed in a 1.25 inch pipe.

Twenty-four runs are reported, made at temperatures up to 1,000°F on feed mixtures, containing from 10 to 30 per cent oxygen, flowing at rates of 3,000 to 7,000 cc. per minute. The four catalysts of Celite and copper oxide on Celite were not selective, producing mixtures consisting mainly of aldehydes and ketones with smaller amounts of alcohols and, occasionally, acids. These useful products contained a maximum of 3.66 per cent of the oxygen fed. If unreacted propane were recycled, a maximum of 7.4 per cent of the fresh carbon feed would have been converted to useful products.

With the catalysts used, temperature was most influential on the reaction, with no products found below 800°F. The temperature control demonstrated by the apparatus was found to be limited by operating temperature, feed composition and the catalyst used. In the ranges studied, feed composition and flow rate had little effect on conversion of oxygen fed. Dehydrogenation of the propane, with the formation of substantial quantities of unsaturated hydrocarbons, was found to accompany yields of useful products. The unsaturated hydrocarbons contained a maximum of 21.5 per cent of the carbon fed. If unreacted propane were recycled, a maximum of 85.0 per cent of the fresh carbon feed would be found as unsaturated hydrocarbons.

The investigation did not reveal the selective catalyst sought but did demonstrate the advantages of a fluidized bed for the control of exothermic reactions. The necessary analysis procedures were complicated and time consuming and limited the information obtainable.

[1]Doctoral thesis no. 1439, submitted July 15, 1953. Chairman of Committee, G.H. Beyer, Department of Chemical Engineering.

[2]B.Ch.E., University of Dayton, Dayton, Ohio, 1948. Graduate Assistant.

ADSORPTION FROM BINARY NONAQUEOUS SOLUTIONS ON NONPOROUS ADSORBENTS[1]

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The adsorption of the hydrocarbons cyclohexane, decane, and dodecane from methanol and ethanol solutions, and of octane from methanol solution was investigated at 25°C on the carbon black Spheron-6, the graphitized carbon black Graphon, and the artificial graphite DAG-1. The purpose of this investigation was to establish experimentally the effects of variation of solute activity, the chain length of solute molecules, the nature of the solvent, and the nature of the carbon surface upon the amount of solute

[1]Doctoral thesis no. 1441, submitted July 16, 1953. Chairman of Committee, Robert S. Hansen, Department of Chemistry.

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adsorbed from solution. It was also the purpose to determine whether the generalizations developed from studying the adsorption of aliphatic acids and alcohols from aqueous solutions were due to the peculiar nature of the solvent, or whether these generalizations had universal application to adsorption from solution. Nonporous adsorbents were used to eliminate capillary condensation effects which obscure the adsorption at the solid-solution interface by effects dependent upon the physical nature of the adsorbent. The amount of solute adsorbed was determined by interferometric measurements of the change in solution concentration brought about by equilibration of the solution with the adsorbent.

All hydrocarbon-methanol systems were of limited miscibility, and adsorption from the methanol phases showed a rapid rise as the solution concentration approached the saturation value. The adsorption values reached in these measurements demonstrate that the adsorption on the adsorbents Spheron-6 and Graphon must be multimolecular; the similarity of isotherms on the adsorbent DAG-1 to those on adsorbents with which adsorption is demonstrably multimolecular indicates that the adsorption on DAG-1 is also multimolecular.

In contrast to the adsorption of slightly soluble aliphatic alcohols and aliphatic acids from aqueous solutions by these same adsorbents, the adsorptions of different hydrocarbon homologues from methanol solutions at the same absolute hydrocarbon activity were not the same but varied systematically along the homologous series, the lower homologues being more extensively adsorbed at high activities.

A theoretical treatment of adsorption is developed for the systems of limited miscibility. The theory presented uses a Langmuir mechanism to describe adsorption in the first molecular layer and a van der Waals force law to describe adsorption in higher molecular layers. The adsorption equation derived is found to represent hydrocarbon-methanol experimental data satisfactorily, and the constants show a physically reasonable variation along the homologous series.

For the miscible systems, the adsorbent Graphon was found to adsorb all hydrocarbons positively over the entire concentration range. The adsorbents Spheron-6 and DAG-1 led to isotherms which inverted at high hydrocarbon concentrations, ethanol being positively adsorbed at very high hydrocarbon concentrations. It is shown that the adsorption of hydrocarbons from ethanol solutions cannot be interpreted reasonably in terms of a preferred molecular structure on the surface, but can be interpreted reasonably in terms of surface oxide complexes and differences in fall-off laws for van der Waals forces from infinite films and semi-infinite slabs. Arguments based on the comparison of isotherms for adsorption of hydrocarbons from methanol and ethanol solutions are presented to show that adsorption of hydrocarbons from ethanol by the adsorbents studied is also multimolecular.

Comparison of the adsorption of hydrocarbons from methanol solutions on the different adsorbents shows that the adsorption on Graphon was the greatest at all concentrations. The difference in the adsorption on Spheron-6 and the adsorption on DAG-1 is explained in terms of differences in fall-off laws of the adsorption potentials for these two adsorbents.

The preferential adsorption of ethanol from hydrocarbon-ethanol solutions on the adsorbents Spheron-6 and DAG-1 is explained on the basis of surface complexes which possess specific affinity for alcohol molecules. The absence of preferential adsorption of ethanol on Graphon is the result of removal of these surface complexes during the graphitizing treatment.

Eight tables of experimental data and nineteen graphs are presented in support of the above observations and conclusions.

SOME CORRELATIONS OF CHEMICAL CONSTITUTION AND PLANT HORMONE ACTION[1]

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A brief survey of the literature was made to determine the present state of knowledge correlating chemical structure with plant growth activity. The survey included several classes of organic compounds. As all these compounds were not tested by the same method, a comparison of the reported activities must be made with the realization that such activities depend not only on the compound but also on the method of testing and on other factors

In the present investigation a number of compounds structurally related to substances of known plant growth activity were synthesized to be tested for formative activity. Most of these compounds were aryloxyalkanoic or arylenedioxyalkanoic acids, derivatives of these acids, or compounds bearing a structural resemblance to them.

A number of oxyalkanoic acids were prepared by the reaction of a phenol (sodium salt) or phenolic-type compound with a haloalkanoic acid or with its aklyl ester followed by saponification. These acids include 2-methoxy-4-chlorophenoxyacetic acid (m.p. 141-143°), 3-chloro-2-naphthoxyacetic acid (m.p. 183-185°), 6-bromo-2-naphthoxyacetic acid (m.p. 226-229°), 5,7-dichloro-8-quinolineoxyacetic acid (m.p. 219° dec.), 5,7-dibromo-8-quinolineoxyacetic acid (m.p. 222-224° dec.), 5,7-diiodo-8-quinolineoxyacetic acid (m.p. 199° dec.), and α-(2,4-dichlorophenoxy) palmitic acid (m.p. 75-76°; amide, m.p. 77-79°; anilide, m.p. 81-83°). The method failed in efforts to prepare 4-chloro-o-phenylene-dioxydiacetic acid, 1,6-dibromo-2-naphthoxyacetic acid, 2-carboxy-4-chloronaphthoxyacetic acid, 4'-(2,4-dinitrophenylamino) phenoxyacetic acid, 1-aminoanthraquinone-4-oxyacetic acid, flavone-3-oxyacetic acid, and 5-sulfo-7-iodo-8-quinolineoxyacetic acid. Ethyl 3-pyridineoxyacetate [b.p. 97-98° (0.2 mm), n^{29}_D 1.5053, d^{28}_4 1.154] was prepared from 3-hydroxypyridine and ethyl bromoacetate. Presumably 2-hydroxyquinoline reacted with ethyl chloroacetate to give, upon hydrolysis, 1,2-dihydro-2-keto-1-quinolineacetic acid (m.p. 282° dec.). No pure product was obtained from the reaction of 8-hydroxyquinoline with chloroacetic acid or ethyl chloroacetate.

Refluxing 48 per cent hydrobromic acid selectively cleaved one ether linkage of 2-methoxy-4-chlorophenoxyacetic acid to give 2-hydroxy-4-chlorophenoxyacetic acid (m.p. 124-126°); refluxing concentrated hydrochloric acid did not effect this cleavage. 2-Hydroxy-4-chlorophenoxyacetic acid was converted to the lactone (m.p. 67-69°) upon heating at 150-155°.

Ethyl o-phenylenedioxyacetate [b.p. 79-81° (0.3 mm.), n^{24}_D 1.5127] was synthesized from catechol (disodium salt) and ethyl dichloroacetate. From this arylene ester were prepared the amide (m.p. 110-112°), hydrazide (m.p. 185-187°), anilide (m.p. 135-137°), and n-butyl ester [b.p. 100-102° (0.3 mm), n^{29}_D 1.4907, d^{28}_4 1.125]. Ethyl 4-chloro-o-phenylenedioxyacetate [b.p. 108-109° (0.4-0.5 mm), n^{29}_D 1.5331, d^{28}_4 1.325] was synthesized from 4-chlorocatechol and ethyl dichloroacetate.

A mixture of unidentified products was obtained in the reaction of 1-bromo-2-(p-chlorophenoxy) ethane with silver nitrite.

2,4-Dichlorophenoxyacetaldehyde diethylacetal [b.p. 106-108° (0.2 mm.), n^{24}_D 1.5065, d^{26}_4 1.190] was synthesized from 2,4-dichlorophenol (sodium salt) and chloroacetal in a reaction carried out at 195-200°. The free aldehyde (m.p. 57-60°) was obtained through acid hydrolysis of the acetal. Derivatives of the aldehyde which were prepared consisted of the semicarbazone (m.p. 181-183° dec.), thiosemicarbazone (m.p. 155-157°), 4-nitrophenylhydrazone (m.p. 184-186°), and 2,4-dinitrophenylhydrazone (m.p. 172-174°). In other trials attempts to prepare the 4-nitrophenylhydrazone and 2,4,6-trichlorophenylhydrazone led to the corresponding bisphenylhydrazone of glyoxal. Attempts to prepare certain other derivatives of the aldehyde failed.

[1]Doctoral thesis no. 1467, submitted November 30, 1953. Chairman of Committee, Henry Gilman, Department of Chemistry.

[2]A.B., Kansas State Teachers College, Pittsburg, Kans., 1949.
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Efforts to acylate thiophene and furan with 4-chlorophenoxyacetyl chloride, using stannic chloride as the catalyst, resulted in intramolecular cyclization of the acid chloride to give 5-chloro-3(2H)-benzofuranone (m.p. 118-120°) as the only product isolated.

A list of compounds which were made available for testing for formative activity is given. Those results which had been received prior to the time of the writing are included.

THE ECONOMICS OF FARM SIZE IN CASH-GRAIN FARMING IN IOWA[1]

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This study was focused on the farm size question. Specifically the objectives were to obtain for the cash-grain farms of central and north central Iowa: (a) an estimate of cost and production coefficients to explain the nature of cost economies and returns to scale; (b) an estimate of the effects of risk and uncertainty on farm size choices. A further objective was to obtain a comparison of alternative techniques in analyzing returns to scale problems.

The basic data for the production and cost function analysis were obtained in 1948 from 187 farm business schedules. A probability sample, modified to yield more nearly equal numbers of farms in all possible size groups was used in obtaining these schedules. A follow-up questionnaire to study the uncertainty aspects of the farm size problem was obtained from a subsample of 115 of these farmers.

The production function analysis indicates that:

1. the optimum sized cash-grain farm is at least twice the present modal sized cash-grain farm in this area;
2. statistically significant increasing returns (decreasing costs) are apparent until the 300 to 400 crop acre size (320 to 480 total acres); within and perhaps beyond this size range constant returns are approximated;
3. the optimum sized cash-grain farm under present technology is one that has 300 to 400 crop acres; the cost economies of farms in this size range are significant and sizeable;
4. the cost advantage or resource efficiency of larger sized farms arise due to internal economies in the proportionality of factors;
5. factors other than explicit rising costs and returns must limit size, or farmers are interested in goals other than those that would be obtained with least cost farm sizes;
6. resource adjustments between resources on cash-grain farms are necessary; the marginal productivity estimates of current operating inputs are high and labor inputs low.

Single equation methods using regressions in the logarithms, or multiple correlation analysis, proved to be more satisfactory than simultaneous equation methods in obtaining estimates of production and cost functions. To examine the nature of short run costs and returns, production and cost functions were fitted to three size group stratifications of the data. The functions were interesting but not significant.

Most cash-grain farms in Iowa are not at the optimal (least cost) size. Why they are not at optimal size may be accounted for in part by the effect of uncertainties and risks that condition the goals, decisions, actions, and outcomes in farming.

Cash-grain farmers believe that:

1. the least cost farm is larger in size than the one they are now operating or larger than the modal unit of north central Iowa;
2. the optimal farm size is an increasing function of equity and a decreasing function of "risk", and that size diseconomies are preferable to the increased chance of insolvency;
3. share renting is more safe than cash renting and under either arrangement the optimal size chosen varies directly with equity position;

[1]Doctoral thesis no. 1552, submitted June 4, 1954. Chairman of Committee, Earl O. Heady, Department of Economics and Sociology.

[2]B.S.A., University of Saskatchewan, Canada, 1946. M.S., University of California, Berkeley, Calif., 1947. Fellow, Agricultural Experiment Station.

4. the greater the price certainty and the greater the equity of the farmer, the greater the optimal size of farm operations;
5. reductions in uncertainties and risks in farming do and will encourage an upward trend in farm size.

Cash-grain farmers "over-invest" in farm power and equipment to meet weather risks. The analysis indicates that (a) on the average 23 per cent more land could be farmed under ideal weather conditions with the machinery farmers have to maintain for normal weather conditions; (b) larger capacity equipment on the larger sized cash-grain farms enables the farm to carry on near maximum operations regardless of weather risks; whereas on small farms much over-investment in machinery must be maintained in order to keep flexible enough to mett the strains and stresses of bad weather; (c) larger machines have more built-in capacity and job flexibility, therefore where farm size adjustment is slow, cooperative, joint or corporate ownership of certain large machines for custom work would reduce risks and overhead on under-the-optimum sized farm units.

The study also provides estimates of the relative costs of operating farms with various machinery combinations, and, by a ranking procecure, "best" or least cost farm sizes were established for cash grain farming in central and north central Iowa. A two-man farm unit, with 320 acres and a specified machinery combination, was the technical unit chosen as being capable of producing at least cost. For one-man farms, the 240-acre unit with a specified machinery combination was the least cost unit in this category. Cash-grain farms from 240 to 480 acres were considered to be least cost units. Farms less than 240 acres were deemed to have considerably higher per-unit costs and farms larger than 480 acres had doubtful rising per-unit costs.

The economies and returns advantages of optimal farm units are real and are recognized by cash-grain farms. The various ramifications of risk and uncertainty do affect farm size choices. A trend to larger farm sizes in response to size economies will be conditioned by the effects of risk and uncertainty. Changes in institutional arrangements and technological developments particularly are reducing the "risks" in farming and thereby facilitating size adjustments. But these adjustments have been slow, therefore if society's goal is efficient food production, programs are needed to remove impediments to expanding farm size. However, society is also concerned with social costs and other goals. Therefore, if society deems it more important to keep the maximum number of farmers on the land, or at least not reduce present numbers, then programs are needed to prevent the trend to larger farm sizes that is taking place in response to size economies and reduced "risks."

IONIZATION YIELDS OF FISSION FRAGMENTS IN GASES[1]

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The present problem arises from a consideration of some of the experimental and theoretical results which were obtained previously, some of which will now be briefly mentioned. Fission fragment mass distributions which were derived from data obtained from double ionization chambers using argon plus carbon dioxide gases disagree with those obtained by means of radiochemical analysis of the fission products. Fission fragment velocity distributions which were also derived from double ionization chamber data disagree with that obtained from a direct measurement of velocities. Further, these double ionization chamber measurements of the total kinetic energy of fission give lower values than those estimated from calorimetric measurements. These disagreements are explained by assuming the W (average energy per ion pair) values of fission fragments stopped in an ionization chamber gas are of the order of 5 per cent larger than those for alpha particles which are used as the basis to calculate fission energies. On the basis that fission fragments lost greater percentages of initial energy

[1]Doctoral thesis no. 1486, submitted December 12, 1953. Chairman of Committee, Glenn H. Miller, Department of Physics.

[2]B.A., Luther College, Decorah, Iowa, 1943. M.S., University of Iowa, Iowa City, 1947. Research Assistant, Institute for Atomic Research.

through elastic collisions and that recoil argon gas atoms had reduced ionization efficiencies, a theoretical calculation in terms of an ionization defect appeared to justify this viewpoint. The ionization defect is thought to arise from energy transfer through elastic collisions and,hence, should be a function of the atomic mass of the gas.

Since in an ionization chamber the secondary ionization efficiencies of recoil gas atoms appeared to play an important part in the stopping of fission fragments, it was of interest in this experiment to determine whether the ionization defect of fission fragments was a function of the mass of the stopping gas.

Ionization distributions were obtained for fission and slpha particles using a parallel-plate gridded ionization chamber employing electron collection. A natural uranium film was irradiated with d-d reaction neutrons to produce fission. Comparison of the most probable pulse voltages for fission fragments with those of alpha particles, combined with known alpha energies, gave the so-called fission energies. Fission energies which were measured in various gases and gas mixtures were compared with each other to determine differences in the ionization defects between gases.

The ionization defects of the most probable fission fragments stopped in helium, neon, nitrogen, argon plus 5 per cent nitrogen, and argon plus 3 per cent carbon dioxide were measured relative to those of argon. These measurements of the differences between ionization defects for fission fragments between gases were made under the assumptions that the alpha particle ionization defects in the gases were not very different and were relatively small compared to the alpha particle initial energy.

Differences in the ionization defects between argon and helium gases were observed to be about one-third as large as those which were expected on the basis of increased ionizing efficiency for lighter recoil gas atoms. The smaller observed differences might be due to changes in the average charge of fission fragments between gases, double ionization in helium gas, and metastable states in helium gas. Differences in the defects between argon and neon gases were not regarded as significant. Since the masses differ by only a factor of two, a large difference was not expected. Large differences in the defects between argon and nitrogen gases and between argon and argon plus carbon dioxide were observed. These were not expected on the basis of the variation of the ionizing efficiency with the mass of the recoil gas atoms, or atomic ionization defect. They were explained qualitatively in terms of a molecular ionization defect. The large magnitude of the difference between argon and argon plus 3 per cent carbon dioxide was surprising in view of the small quantity of carbon dioxide present. Differences in the defects between argon and argon plus 5 per cent nitrogen were not regarded as significant although the presence of 5 per cent of a molecular gas might be expected to give rise to a small difference.

The differences between ionization defects in argon and argon plus carbon dioxide gases was used as a basis to suggest that the ionization defect attributed to argon gas might not be as large as has been indicated and that the discrepancey in the measurements of the ionization defect for alpha particles in argon gas might be resolved.

The operating characteristics of a gridded parallel-plate ionization chamber were investigated, and the particular effects, such as electron multiplication about the grid wires, ratio of fields for complete electron collection, rise time of ionization pulses, and alpha and fission saturation curves, were observed as a function of the chamber gases. A correlation was observed between the minimum ratio of fields necessary for complete electron collection in a gas and the calculated magnitude of the electron diffusion in the gas. Mention of this correlation has not been found in the literature. Multiplication of electrons about the grid wires was observed for argon and neon gases.

Alpha particle saturation curves in the various gases have been observed with greater precision than those which have been found in the literature.

A relatively simple method of making large, uniform, natural uranium sources was devised and used in the present experiment. It appears readily applicable to making source thicknesses over the range from a few micrograms to several milligrams per square centimeter.

The use of mixtures of argon plus carbon dioxide gases in the present chamber has been found to produce some undesirable characteristics. Saturation characteristics for alpha particles appeared to be a function of the per cent of carbon dioxide present in the argon and of the pressure of the gas mixture. Mixtures of argon and nitrogen gases appeared to give the same desirable characteristics as the argon and carbon dioxide mixtures without the apparently undesirable effects.

The relative values of $W\alpha$, using electron collection in the present experiment, compared well with the literature values, which were obtained using total ion collection.

PERSONAL, SOCIAL, AND ECONOMIC FACTORS CONDITIONING FARMERS' DECISIONS AND RESOURCE USE ON CENTRAL PENNSYLVANIA DAIRY FARMS[1]

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Past farm management studies show that few farmers attain the simple optimum position characterized by perfect knowledge and unlimited capital. Why do farmers not adjust their operations to the equilibrium assumed in classical theory and conventional research?

Some writers maintain that farmers lack knowledge of the principles involved, of the production coefficients and price data concerning factors and products. Others maintain that farmers have all this knowledge; that forces such as institutional arrangements (leases, marketing quotas, pricing policies, etc.) condition their adjustment to the optimum. Still others emphasize that it is economic uncertainty or the value system of the individual farm operator (his goals or objectives in life, his standard of attainment, etc.) that keeps the farm firm from attaining the simple optimum of static theory. There has been little empirical work to test these several hypotheses or assumptions.

It was toward this end that this study was undertaken with the following specific objectives in mind:

1. To determine the factors or conditions responsible for the deviation of the present position of the firm from some "feasible and desirable standard of performance."
2. To determine reasons why the entrepreneur does not take the necessary steps or measures to improve on his firm's position.

The study was confined to an analysis of the dairy enterprise for two important reasons. First, approximately 41 per cent of gross market receipts to Pennsylvania[1] farmers in 1950 was derived from the dairy enterprise. Secondly, a complete labor income statement and a cost of milk production schedule was available for the 1948-49 year on a large group of central Pennsylvania dairymen which could be sampled for this study. These reasons seemed to justify concentrating attention on the dairy enterprise. Only owner-operator dairymen were questioned because of a tendency for tenants to rationalize many of their decisions and actions in light of their tenure arrangements. Questionnaires on 151 owner-operators were analyzed for this study. Major attention was given to the role of knowledge, capital rationing and certain psychological and sociological factors in explaining farmers' actions.

The results of the knowledge test, which quizzed the farmer on the technical phases of dairy production, suggested that a high proportion of our farmers lacked much of the basic knowledge required for proper decision-making. (Scores ranged from 96 down to 10 with an average score of 66 based on a perfect score of 100). The gap between the present state of knowledge of many farmers and that required actually to adopt improved practices is apparently greater than frequently appreciated. The importance of overcoming knowledge deficiencies is suggested by the fact that those operators who made high scores on the knowledge test had higher-producing herds which yielded higher returns above feed costs per cow, and were operating farms which earned much higher labor incomes as well. Thus we very often find only mediocre levels of performance on farms operated with insufficient knowledge when the available resources might suggest much higher levels of accomplishment. These facts would seem to support the notion that improvement in farmers' knowledge would serve to improve the efficiency and profitableness of many farming operations. However, since proper knowledge was found to be related to many other desirable personal characteristics and to apparently correct decisions, it is difficult to determine how much of farming success can be attributed solely to proper knowledge.

Despite the importance of knowledge, the study makes it clear that lack of knowledge by no means accounts for all of the failures to adopt appropriate measures. A farmer

[1]Doctoral thesis no. 1493, submitted December 14, 1953. Chairman of Committee, Earl O. Heady, Department of Economics and Sociology. This study was conducted in 1949 as Project No. 1116 of the Pennsylvania Agricultural Experiment Station, the Pennsylvania State University, State College, Pennsylvania. The author was a member of the staff of the Department of Agricultural Economics and Rural Sociology of that institution at the time of the study.

[2]B.S., Pennsylvania State College, 1947. M.S., Iowa State College, Ames, Iowa, 1948. Instructor.

may have full appreciation of the profitableness of the measure under consideration, of the costs involved, and possess the necessary knowledge to carry through with the practice as recommended, but why does he not take the appropriate action? The answer quite frequently, as evidenced by this study, is a lack of necessary funds. Thirty-eight per cent of the operators in this study indicated need for additional funds to effect certain desired measures regarding the dairy alone.

We further ask ourselves--if these operators fully appreciate the need for additional funds to effect the measure, do they intend to obtain the necessary credit? Eighty-eight per cent of the operators expressing a need for additional funds felt certain that they could obtain the needed credit. Out of these 51 operators who felt the credit to be available, 45 indicated a preference not to borrow the needed funds, thus pointing up an internal capital-rationing problem. Making credit available is bot the solution to the capital rationing problem in these instances. The existence of current indebtedness and uncertainty explained the hesitancy to borrow in half the cases, while another 17 of the 45 operators indicated that they "just do not like to borrow money."

Assuming that knowledge and capital limitations were removed, could it be assumed that the firm would automatically approach some optimum level of performance? For this to be accomplished, the operator must be interested or motivated to operate his farm in the most profitable manner. If the necessary motivation is lacking, the removal of capital and knowledge limitation may not produce the expected improvement in the farm's operations.

This study suggests that the dairyman's concept of "good" production or his "standard of good production" (as reflected by his culling level) apparently serves as a source of motivation to improve his herd's production. It was shown that those operators with high "concepts" and "standards" were operating dairies with herds averaging well above their neighbors who had lower "concepts" and "standards".

Another source of motivation is derived from how the farmer thinks his herd's performance compares with his neighbors. It was found that those operators who tend to under-rate their herd's performance are actually operating herds with unusually high production and returns above feed costs. Whereas, those who felt their herd's performance would rank them much higher than they actually are, when compared on an actual data basis, are operating dairies with lower producing herds yielding only fair returns above feed costs. The fact that some farmers think their herd's performance is much better than it actually is (as compared to their neighbors) may discourage them from taking the appropriate measures to improve their production. These data suggest that farmers' concepts and self-ratings may be quite influential in affecting their performance and, hence, imply that they constitute a general problem area of considerable importance to both research and extension workers.

Basically this study has been concerned with the importance of such factors as knowledge, capital, and such human attributes as operator's concepts and self-ratings which frequently have been neglected in farm management research and education. As such, it has succeeded in pointing out that these and other factors associated with the complex human factor in agriculture may be of strategic importance in explaining farmers' actions in the use of their resources. On the other hand, it has not moved very far towards a fundamental explanation of farmers' actions and decisions or in qualifying their relative importance. The experience gained in this analysis strongly suggests that real progress in this direction will require the concentrated and coordinated attention of psychologists, sociologists, and economists to specific problem areas such as economic and psychological uncertainty, motivation, and goals.

BELIEFS OF FACULTY CONCERNING FUNCTIONS AND QUALIFICATIONS OF THE HOME ECONOMICS ADMINISTRATOR IN LAND-GRANT INSTITUTIONS[1]

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The purpose of this study was to determine beliefs of selected administrators and home economics staff members regarding functions and qualifications of home economics administrators in land-grant institutions.

Statements of 70 functions and 28 qualifications were formulated, based on democratic principles of administration. A panel of 14 individuals judges the proposed statements on the basis of soundness, clarity and completeness. A questionnaire was then prepared to secure beliefs of selected administrators and home economics staff members as to soundness of the proposed functions and helpfulness of the qualifications in effective administration.

Forty-two land-grant institutions which met these criteria were selected: grants degrees in home economics, participates in home economics research and extension work, and is located in continental United States. Since a homogeneous group was desired, institutions for Negroes only were excluded. Questionnaires were sent to the following administrators in the 42 institutions: president, head of home economics, home demonstration agent leader, dean of agriculture, director of experiment station, director of extension and dean of the graduate school. In addition, questionnaires were submitted to a random sample of 500 resident and extension staff members and to the panel.

Sixty-five per cent of the 786 questionnaires were returned. The section concerning qualifications was completed correctly by 83 per cent of the 514 who replied to the questionnaire. The largest percentages of returns received were from heads of home economics and home demonstration agent leaders, 83 and 73, respectively. Approximately 69 per cent of each of the academic ranks in the resident staff group responded.

Analysis of the findings indicated that one function was believed wholly sound by 97 per cent of the 514 respondents and one was judged sound by only 37 per cent. Eleven of the 70 functions were believed completely sound by 90 per cent or more of the total group. The panel members unanimously accepted 25 of the 70 functions as sound and their approval of only two statements was as low as 50 per cent.

When responses of home economics administrators and presidents were compared, it was found that they differed more than 15 per cent in acceptance of 12 functions. In eight instances approval of the former was greater than that of the latter. The home economics administrators and resident staff also differed more than 15 per cent in acceptance of 12 functions. The administrators approved of these 12 statements to a greater extent than staff members.

Of the 70 functions to which respondents were asked to react, 67 were believed wholly sound by at least 50 per cent of the total group and of the panel:

> Assumes leadership in: formulating departmental goals that are sound; seeing that these goals are consistent with institutional goals; developing and evaluating departmental curricula; helping staff improve quality of teaching; helping staff build an educational philosophy and scrutinize and revise it, as needed; helping staff develop an awareness that a major goal is development and general welfare of students; helping staff keep constantly in mind that a major goal is strengthening family living; stimulating staff to participate effectively in general institutional activities.
>
> Takes final responsibility for, but creates machinery through which staff members may participate in decisions concerning: departmental budget; recommendation of individuals for appointment to staff.
>
> Promotes work of the department by: assisting staff members in defining duties clearly; assisting staff in equitable division of duties among its members; cooperating in coordination of specialized interests and activities of staff into an effective total organization; stimulating staff to participate effectively in departmental efforts; allowing adequate flexibility for staff members to "grow" in ability to take responsibility; recommending for selection, administrative heads of units within the depart-

[1]Doctoral thesis no. 1453, submitted August 6, 1953. Chairman of Committee, Hester Chadderdon, Department of Vocational Education.

[2]B.S., Iowa State College, Ames, Iowa, 1932. M.S., Ibid., 1940. Instructor.

ment on the basis of overall interest in home economics as well as qualifications of leadership in a specific area; assisting in improvement and maintenance of an environment conducive to working cooperatively and effectively toward departmental goals; encouraging evaluation of use of resources.

Makes provision for: applicants for staff positions being informed of institutional and departmental philosophies; applicants for staff positions being informed of arrangements that affect their personal welfare; newly appointed staff members being helped to understand operational details of institution and department; staff having a clear knowledge of departmental and institutional policies; staff and students participating in development and revision of general departmental policies.

Furnishes opportunity for staff to evaluate and recommend rewards for: contributions of staff members; professional growth of staff members; professional growth of students.

Provides, as far as possible, conditions which stimulate staff members to: do professional creative work; continue professional development; contribute to professional organizations.

Works with professional and nonprofessional staffs toward: attainment of reasonable balance among work, home, and outside activities; maintenance of friendly atmosphere.

Stimulates staff and facilitates their use of such means as press, radio, TV, short courses, talks and demonstrations to: keep general public informed of departmental program; help families of state with problems; cooperate with various agencies concerned with family life education.

Helps to keep channels of communication functioning effectively.

Cooperates with administrative officers and faculty in: developing institutional goals; executing institutional policies; facilitating participation of home economics staff in formulation and evaluation of institutional policies; promoting establishment of policies of mutual benefit to professional and nonprofessional staff and the institution; conforming to institutional business procedures, preparing statements, for use in informing state officials, of accomplishments and needs of staff and students of the department.

Helps general institutional administrator to develop and maintain a sound understanding of home economics and its relationship to the broad purposes of the institution.

Exercises leadership in providing conditions by which students may be helped to evaluate: their own development; extent to which curriculum meets their needs.

Helps create a program that will foster the understanding among students that education is a life-long process.

Makes self available and urges staff to be available for contacts with students to become familiar with their needs and interests.

Shows active interest in providing facilities for the physical, spiritual, civic and social growth of all students on campus.

Maintains contacts with alumnae to: indicate personal interest and help them develop professionally; seek their evaluation and suggestions for improvement of departmental program.

Stimulates general administration, faculty, students, extension personnel and alumnae to: familiarize prospective students and their parents with possibilities for personal growth and professional opportunities in home economics; encourage prospective students to avail themselves of these opportunities.

Cooperates with existing institutional agencies, or helps improve them if such are not adequate, in: placing students and alumnae in positions; keeping personnel records of students and alumnae in an up-to-date, permanent form; counseling of students.

Encourages increased understanding and exchange of ideas for improvement of the educational program: among staff members within department; among staff members within institution; between community and departments; with campus visitors.

Maintains working relationships with agricultural experiment station in furthering research work by sharing in: planning and evaluating the program; securing a competent staff; providing physical resources; planning and using the budget.

Maintains working relationships with the agricultural extension service by: encouraging exchange of ideas between resident and extension staff members regarding program planning, subject matter and research; assisting in provision of needed resources.

Maintains working relationships between home economics and other departments of institution in: developing programs to meet new needs; providing courses in family life basic to general education; offering courses to non-home economics students for their professional education.

Inspection of the data indicated need for these revisions of two statements and addition of a third: (1) participates actively in general institutional activities, (2) maintains working relationships with the agricultural extension service in helping to find personnel and (3) delegates responsibility, with sufficient authority, to qualified individuals or groups for the performance of designated functions.

Directions for the section of the questionnaire on qualifications limited respondents to selection of five of 28 qualities that would help and five that would hinder the candidates in effective administration. These 15 qualities were believed by 50 per cent or more of the respondents to affect a candidate:

Has skill in helping the staff and students assume some departmental responsibility; has a friendly approach to people; maintains good physical and mental health; possesses poise and self-assurance; uses experimental approach to solution of problems, when feasible; gives credit to staff for contributions to departmental affairs; maintains broad interests in addition to deep interest in professional work; has a broad vision of home economics including a deep concern for family life education and its place in higher education; understands clearly the purposes and principles of sound administration and is governed by them; arrives at decisions through careful consideration of human values as well as efficiency of operation; has skill in evaluating the relative importance of matters needing attention; takes action in situations at the right time; organizes department so the parts contribute to the effectiveness of the whole; communicates effectively with staff, students, administration, professional and lay groups, accepts each individual for his own worth with freedom to develop.

This investigation suggests the need for further studies: (1) conditions under which administrators could perform the functions believed sound, (2) determination of satisfactions derived from administrative work, (3) beliefs regarding functions of home economics administrators in liberal arts, teacher-training and Negro institutions, (4) means of identifying qualifications considered desirable in cadidates for administration in home economics and (6) analyses of differences in responses of the academic groups.

RADIOCHEMICAL STUDIES ON THE PHOTOFISSION OF THORIUM[1]

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Department of Chemistry

Photofission was induced in thorium metal by irradiation in the 69-Mev beam of the Iowa State College synchrotron. Radiochemical methods were used to determine the photofission yields at thirteen different nucleon numbers. Using these experimental points it was possible to estimate the shape of the photofission yield curve of thorium.

The photofission yield curve of thorium had the familiar "double-humped" shape common to most fission yield curves. The ratio of most probable yield to symmetrical yield was ten; the width of the peaks at half-height was twelve mass units, and the maximum yields were 6.9 per cent at nucleon numbers 91 and 138. The nuclei which underwent photofission emitted an average of three neutrons.

Hydrochloric acid was found to dissolve thorium metal with a rapidity which is unique among all the acids. In order to achieve this rapid dissolving action, it was found necessary to use a minimum of three gram-molecules of hydrochloric acid per

[1]Doctoral thesis no. 1300, submitted May 21, 1952. Chairman of Committee, Don S. Martin, Department of Chemistry.

[2]A.B., Miami University, Coral Gables, Florida, 1948. E.E., University of Nebraska, Lincoln, Nebr., 1947. Research Assistant, Institute for Atomic Research.

gram-atom of thorium. The remainder of the necessary hydrogen ion was supplied with equally good results by hydrochloric acid, perchloric acid or sulfuric acid.

New radiochemical methods were devised for separating cadmium and cerium from the acidic thorium matrix solution. Cadmium was separated by the use of thiourea and Reinecke's salt (Nh_4 $[Cr(CNS)_4(NH_3)_2] \cdot H_2O$). Cerium was separated by extracting the thorium into mesityl oxide from a solution saturated with aluminum nitrate, then extracting the rare earths into tributyl phosphate and stripping them out with water. The cerium was then separated from the other rare earths by repeated cycles of bromic acid oxidation, iodate precipitation and hydrogen peroxide reduction. In addition, a method for separating iodide and bromide from the hydrochloric acid solution of thorium and from each other by means of controlled oxidation with cerium(IV) prior to carbon tetrachloride extraction was successfully developed.

Although experimental information is not yet as extensive as might be desired, the following general statements about the photofission process seem justified:

1. The peaks of the photofission yield curve increase in width with the nucleon number of the excited nucleus, but are always narrower than the peaks of the yield curves resulting from neutron fission of the same nuclei.
2. The ratio of the most probable mode of fission to symmetrical fission increases with the nucleon number of the excited nucleus.
3. The light side of the photofission yield curve essentially coincides with that of the corresponding (n, f) curve, whereas the heavy side seems to be shifted more than one nucleon number in the light direction.
4. The neutron yield of the photofission process is little if any larger than that of spontaneous fission.

CYTOHISTOLOGICAL RESPONSES OF VARIETIES OF AVENA TO 2,4-D[1]

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A study was made of the histological responses of two varieties of Avena, Andrew and Cherokee, to the n-butyl ester of 2,4-dichlorophenoxyacetic acid. Plants were treated at 12 stages of development with one pound acid equivalent of 2,4-D per acre.

The developmental histology of the oat plant was studied from germination to emergence above the soil prior to treatment, and subsequently after each treatment until the sporocytes were evident.

The plumule of the mature kernel of oats has two leaf primordia. The third leaf primordium is initiated seven days, and the fourth leaf nine days after planting. Three seminal roots arise endogenously at the scutellar node during germination.

The inflorescence was initiated from 17 to 20 days after planting. Branch primordia of the first-order branches were evident by 26 days after planting. Spikelet initiation occurred 30 days after planting. The initiation and development of the gynoecium lags behind anther initiation by three to four days. Archesporia were initiated 34 days to 38 days after planting.

Treatments were begun nine days after planting, when 85 per cent of the plants had emerged through the soil. The response of both varieties to 2,4-D is similar with respect to the trend in reduction of yield at successive treatments.

Treatments at 9, 12, and 17 days after planting (2, 5, and 10 days after emergence from the soil), induce a change in histogen activity in the shoot apex. Fasciation and abnormal leaf initiation occur. The duration of transition to the flowering phase is prolonged, but floral organogeny is interrupted.

Treatments at 22 and 26 days after planting result in severe necrosis of the first-order branch primordia. Fasciation in the shoot apex gives rise to multiple inflorescences. Spikelet initiation is suppressed in the apical region of the young inflorescence. Tissues of the lower nodes proliferate and produce fasciated roots, which soon abort.

[1]Doctoral thesis no. 1389, submitted May 27, 1953. Chairman of Committee, John E. Sass, Department of Botany and Plant Pathology.

[2]B.S., New Mexico State College, State College, N.M., 1950. M.S., Iowa State College, Ames, Iowa, 1952. Graduate Assistant, Agricultural Experiment Station.

The intercalary meristems proliferate and elevate the axillary branch, which becomes suppressed. Internodal tissues do not differentiate normally, and remain thin-walled, and soft and brittle.

The treatment 30 and 34 days after planting suppresses spikelet initiation and suppresses the development of branches of higher order. Spikelet fasciation occurs frequently in plants treated 34 days after planting.

The treatment 38 days after planting results in suppression of organogeny in the floret. Malformations and adnation of floret organs occurs during organogeny. The ovule fails to develop in florets which were treated during the initiation of this organ. The initiation of sporocytes is inhibited. The ovule may proliferate and abort.

Tillering was uniform under all treatments, and yield reductions in the tillers results from the same responses as in the main axis.

ECONOMICS OF WESTERN RANGE RESOURCE USE[1]

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The central economic problem relative to range resource use is the allocation of all scarce resources available to the Western Range Area so as to obtain a maximum of the goods and services desired by all individuals and groups concerned. The resources considered were: 1. All land resources west of the eastern boundary (placed near the 100th meridian), including climate as well as phsyiographic features; 2. All labor resources available to the area, including the skills, productivity, and mobility of the workers; and 3. All capital and management resources available to the area.

The primary purpose of this study was to develop a logical framework for economic analysis of western range resource use. The basic deductive theorems of the framework were taken from general equilibrium theory and welfare economics adapted to dynamics.

The marginal conditions underlying the theoretical models were enumerated, their limitations to specific situations were pointed out, and the policy and research implications of the maximizing solutions were discussed.

In general, the economic problems of range resource use fall under four main types of theoretical solutions: 1. Optimum factor combination and use; 2. Optimum scale of firms; 3. Optimum product combination; and 4. The pricing of factors and products. The latter set of problems arises out of the environment in which some of the factors and products are rationed and their respective prices are administered.

The marginal conditions governing the optimum combination of factors of production specify that factors be so allocated that the ratio of the discounted expected marginal value of product to the discounted expected price of the factor be equal for every resource. This ratio should also be equal for every possible alternative use for each factor. (In absolute equilibrium this ratio would be 1.00.) The physical input relationships needed for making maximizing solutions come from the science of range management. However, the logic of the maximizing principles is not a part of the theories and principles of that science, but come from the science of economics.

Optimum scale of firms occur when it is impossible to increase or decrease the size of firms and thus obtain a lower cost of production for the same products or increase the amount of products from the same resources. There is strong evidence that substantial scale maladjustment occurs with the smaller firms. The extent of conflict between resource efficiency and income distribution criteria for determining optimum scale adjustment depends on the real nature of the economies of scale. There are conflicts in the kind of recommendations one makes based on each criteria.

An important assumption underlying the necessary marginal conditions for maximum welfare is that the factors and products are priced so that the market is cleared of all factors and products that are offered at that price and that no demand at that

[1]Doctoral thesis no. 1553, submitted June 4, 1954. Chairman of Committee, Earl O. Heady, Department of Economics and Sociology.

[2]B.S., University of Wyoming, Laramie, Wyo., 1942. M.S., Ibid., 1949. Instructor.

price goes unsatisfied. This assumption was found to be invalid for several instances of federally owned forage resulting in pressures tending toward malallocation. A general procedure was presented for evaluating the forage in terms of: 1. The quantity and quality of forage and the production coefficient rate at which grass was transformed into animal product; 2. The price of livestock products; and 3. The cost of resources other than forage associated with range-livestock production.

The marginal conditions specifying an optimum combination of enterprises (products) were explored for three different types of allocation problems. The first was that of determining the type of agricultural production for areas that are marginal between range-livestock production and dryland cropping. A part of this problem, for some regions, is the integration of irrigation into range and dryland farming operations. The existing economic criteria for determining the feasibility of irrigation development was appraised.

The second type of product combination to which the marginal conditions were applied was that of determining the optimum rate of product (resource) use over time. This is the general problem of conservation.

A theoretical model for determining optimum intensity of grazing over time was developed and adopted to conditions of weather uncertainty.

The third type of product combination pertained to the optimum combination of the products of multiple-use resources, viz., livestock, wildlife, timber, recreation, and hydrological products. The general solution to this problem was approached through a series of partial solutions.

In each case the solution was a function of the physical marginal rates of product substitution between the two alternatives in question for a specific range site and the relative preferences of society for the products being considered. The general nature of several physical transformation functions was suggested, and procedures for estimating others were outlined.

The relative preferences of society for alternative products is usually expressed in terms of market prices. Not all products are allocated through the market mechanism, however. In some cases individuals express their preferences for alternatives by voting. Many of the allocation decisions pertaining to range resource use have been delegated to elected and/or appointed representatives. The complex and interrelated allocation decisions that are made by the several different elected and appointed representatives (Congress, the President, and the bureaucracy) can be improved by the use of: 1. A central planning and coordinating board; and 2. A professional sampling staff to estimate the preferences of individuals relative to alternatives by means of statistical sampling.

Where the information needed for a decision is known, the theoretical models lead directly to the maximizing solution. Where the information is not known, the models direct the search for the needed facts. In the meantime they furnish the only logical basis for decision making in the absence of information.

STUDIES IN EFFICIENCY OF THE AIR-STREAM ATOMIZATION PHENOMENA[1]

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An experimental investigation was conducted in which distilled water under normal atmospheric conditions was atomized by a high velocity air stream. The atomizing unit (which also could be used for solid-injection atomization) consisted of a glass convergent air nozzle with a short straight section and a concentric hypodermic tube for the purpose of water injection. The purpose of the investigation was to determine the effect upon the efficacy and comparative degree of atomization by using various methods of water injection, and by varying the injection position along the axis of air flow, for use in possible engineering applications. The sprayed droplets were collected on mag-

[1]Doctoral thesis no. 1434, submitted July 14, 1953. Chairmen of Committee, Henry Black, Department of Mechanical Engineering, and E.W. Anderson, Department of Mathematics.

[2]B.S., University of Illinois, Urbana, Ill., 1944. M.S., Ibid., 1949. Assistant Professor.

nesium oxide coated glass slides, housed in a specially constructed sampling apparatus which exposed the slides for an appropriate time. Three samples were taken for each test at the horizontal axis of the spray, and under a calibrated microscope counted until no appreciable difference in droplet distribution was noted. From the droplet distribution the volume-surface or Sauter mean-diameter, d_o, in microns was evaluated. Precautions were taken against drop evaporation and possible settling out of drops before reaching the sampling apparatus.

The air velocity, v_a, was varied from 106 to 316 m. per sec. The air to water volume ratio, Q_a/Q_w, was varied from 1.000 to 20,000. The water rates used were small, and, consequently, the water velocity never exceeded one m. per sec. Four different methods of injection were used: One utilized water injection parallel to the ambient air stream and the others with various types of orifices used injection normal to the air stream.

In light of this investigation, the following conclusions can be made. Liquid injection parallel to the air stream results in a better degree of atomization than liquid injection normal to the ambient air stream. The former method does not seem to impair the normal process of attenuation of the liquid surface, ligament formation, and drop formation as does the latter method. Differences in the degree of atomization in the latter methods depend principally upon the amount of liquid surface that comes in contact with the high velocity air.

With liquid injection parallel to the ambient air stream, for the best degree of atomization the mass of liquid should enter the region of maximum velocity. For the convergent nozzle used, the maximum v_a attainable is acoustic. At this velocity and for $Q_a/Q_w > 5000$, d_o tends towards a lower limit. This lower limit may range between 5 and 7 microns for the atomizing unit used. These low values for d_o in the proximate vicinity of the acoustic velocity is not in agreement with the experiments of Nukiyama and Tanasawa. Their empirical equation predicts higher values, but otherwise present experimental results compare favorably with the investigators mentioned. For $v_a <$ 100 m. per sec. and $Q_a/Q_w < 1000$ the degree of uniformity of the drops decreases rapidly. For $Q_a/Q_w > 5000$, d_o is independent of the liquid rate and depends on v_a (for low liquid velocities), decreasing as v_a increases.

The angle of spray dispersion increases as the point of liquid injection is varied from upstream of the exit of the nozzle and on through the straight section of the nozzle. For $v_a > 150$ m. per sec., d_o does not appreciably vary over an interval, which with respect to the nozzle exit extends through the straight section and one-half an inch downstream. Consequently, the spray angle may be varied by manual adjustment without appreciably varying the droplet size.

A dimensional number is developed and is termed the atomization number, A_N. It is in effect, the ratio of the kinetic energy of the air to the actual superficial potential energy of the droplets formed, and it serves as an adequate index of the efficacy and comparative degree of air-stream atomization for various atomizing units.

SOME COST RELATIONSHIPS IN LARD PROCESSING[1]

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Department of Economics and Sociology

The study was designed primarily to discover the short-run input-output relationships in the rendering department of a packing plant employing a specific process. Input factors were valued at constant relative prices for purposes of aggregation as well as for comparisons between costs. It was hoped to discover the variations in costs that are dependent upon changes in production.

Emphasis was placed on methodology. This was required because of the nature of the data and because the study was to serve as a guide to similar investigation of other plants and as a basis for further investigation in similar or related fields. The inputs

[1]Doctoral thesis no. 1519, submitted March 15, 1954. Chairman of Committee, Geoffrey Shepherd, Department of Economics and Sociology.

[2]B.A., University of Saskatchewan, Canada, 1938. B.S.A., Ibid., 1940. Research Associate, Agricultural Experiment Station.

supplied by the power department comprise about fifty per cent of the cost of producing lard. The cost of the various components of power, such as steam and water, varied with their output. But their output depends upon the volume of production of the whole plant as well as a number of exogenous factors. In order to obtain estimates of the cost of the power components from which the effect of the exogenous factors has been removed it was necessary to study the power department separately. The two departments of rendering and power, therefore, and the individual items of cost that occur in each department were examined. In the rendering department the method of covariance was used to analyze the labor date. The within-quarter regression equation was obtained as the best estimate of the relationship between the inputs of labor and the outputs of product. In the power department the various components of power were examined by means of multiple regression to determine their relationship to exogenous factors affecting the quantity of each used.

It was found that a large portion of the costs of operating a rendering department are fixed costs. Some costs such as rent and taxes and others are wholly fixed costs. Other costs are entirely variable. The labor employed for operating the department, for example, may all be treated as variable. Some labor, such as that of janitors and night watchmen, is to a large extent fixed, but accounting procedure was such that the cost of the operating labor was kept separate and so could be treated as a variable cost in its entirety.

Still other costs are heterogeneous in that they contain elements of both fixed and variable costs. In the case of two such heterogeneous costs it was not possible to divide them into their fixed and variable elements, nor was it possible to discover the relationship of the variable element to output. These two costs were depreciation and maintenance and repair. It was decided to treat them as fixed costs. In the case of other heterogeneous costs it was possible to obtain estimates of at least some of the elements which should be considered as fixed. Many such elements were functions of factors other than production. The variations in costs due to such exogenous factors were removed from the cost components and treated as fixed costs. One item of cost to the rendering department which contained many such components having both fixed and variable elements of cost was power. The power department was studied, therefore, with the purpose in view of removing the effect of exogenous factors and determining the relationship of input of power (which is the output of the power department) to the output of the plant.

It was found that over the range of output of the plant the total cost of power increases at a decreasing rate. The marginal cost of power at highest outputs appeared to be about one-fifth the amount it was at the lowest volumes at which the plant was operating. The costs of power to the rendering department operating at a given level of production are substantially less, therefore, when the plant is operating at the larger volumes of production than when the plant is operating at smaller volumes of production.

The proportion of the cost of power used by the rendering department was then charged to the cost of producing lard. This cost together with the other costs incurred in rendering were aggregated to give total costs. The data indicated a straight-line regression. The regression of total costs on outputs of lard gave the estimating equation

$$\hat{Y} = 4877.1 + 1.1202\ X.$$

The value of $r = 0.903$ with nine degrees of freedom is highly significant. The marginal cost of producing lard, therefore, is 1.12 units of cost per unit of output. The average cost of producing lard was found to be about 3.35 units of cost per unit of output.

It was found that the accounting data gave very little indication of the variation in cost that occurs with variation in output. Unless further analysis of the data is made to obtain this information, a detailed and frequent accounting procedure does not serve a purpose commensurate with its cost. Annual estimates would serve almost as well and would cost considerably less. In an industry where the methods and processes have been established and evaluated for a long period of time there is also less need for an intensive accounting system. For the most part this is the case in the packing industry. Where new processes are being tried, a more intensive system integrated with a complete analysis of the data would be justified.

THE KINETICS OF THE HYDROGEN PEROXIDE OXIDATION OF SELENIOUS ACID[1]

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The rates of disappearance of selenious acid and hydrogen peroxide have been measured in aqueous acidic solutions containing the two species. Temperature variation of these rates has been observed between 67.7°C and 82.3°C.

The following rate law has been determined for the oxidation of selenious acid by hydrogen peroxide:

$$-\frac{d(H_2SeO_3)}{dt} = \frac{k_1(H_2SeO_3)^2(H_2O_2)}{(H^+)}$$

The decomposition of hydrogen peroxide in aqueous acidic solution has been shown to be inhibited by the presence of a small amount of selenious acid. Another mode of decomposition of hydrogen peroxide has been shown to exist and has been found to be first order in selenious acid. At least four rate terms were required to account for the decomposition rate of the peroxide.

The evidence indicated that the reactions which involved selenious acid were homogeneous.

The selenious acid oxidation is believed to be nonfree radical in character while the extra hydrogen peroxide decomposition which accompanies it is believed to proceed through a free radical chain mechanism.

[1]Doctoral thesis no. 1534, submitted May 28, 1954. Chairman of Committee, Don S. Martin, Department of Chemistry.

[2]B.S., Creighton University, Omaha, Nebr., 1947. Jr. Chemist. Research Assistant, Institute for Atomic Research.

RADIOACTIVE DISINTEGRATION SPECTRA OF SOME SHORT-LIVED NUCLIDES[1]

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The beta endpoint energies of several short-lived, low Z radioactive nuclides have been measured with an improved scintillation spectrometer (1). These values have been combined with recent half-life determinations to give the ft values.

TABLE 1

Endpoint Energies, Half-lives, and ft Values for Some Superallowed Transitions

Nuclei	Endpoint (Mev)	Half-life (seconds)	ft (seconds)
Mg^{23}	2.95 ± 0.07	10.7 ± 0.7, (2)	3600 ± 500
Si^{27}	3.76 ± 0.08	4.05 ± 0.10, (2)	4000 ± 450
S^{31}	4.50 ± 0.10	2.40 ± 0.07, (2)	5150 ± 600
Ca^{39}	6.10 ± 0.15	0.90 ± 0.05, (3)	7250 ± 1000
Cl^{34}	4.45 ± 0.10	1.58 ± 0.05, (4)	3000 ± 400
K^{38}	5.06 ± 0.11	0.95 ± 0.03, (4)	3300 ± 400
P^{30}	3.31 ± 0.07	150, (5)	

[1]Doctoral thesis no. 1506, submitted January 25, 1954. Chairman of Committee, D.J. Zaffarano, Department of Physics.

[2]B.S., University of Oklahoma, Norman, Okla., 1948. M.S., Ibid., 1949. Research Assistant, Institute for Atomic Research.

For the group of superallowed transitions, the ft values times $\left|\int 1\right|^2$, (6) increase with mass.

The ratio of gamma-ray intensity above 0.6 Mev to the intensity of the 0.51 Mev annihilation peak was less than two per cent.

A 15 per cent resolution at 624 kev was obtained with the anthracene crystal and photomultiplier tube. The linearity of the scintillation pick-up and recording equipment was tested with the 1.70, 2.24, 4.45, and 13.4 Mev beta endpoints of P^{32}, Y^{90}, Cl^{34}, and Li^8, respectively.

The targets, calibration system, and master control system which are used with the improved scintillation spectrometer are described. The control system automatically cycled the synchrotron, target and recording system until a sufficient number of events to yield the desired statistical accuracy had been obtained. Seventy discrete channels of information were obtained with the multichannel analyzer. (1)

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AN EXTENSION OF PRELIMINARY TESTS OF SIGNIFICANCE PERMITTING CONTROL OF DISTURBANCES IN STATISTICAL INFERENCES[1]

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Department of Statistics

In this thesis a generalized procedure for pooling estimators was proposed in an attempt to reduce the magnitude of the disturbances in statistical inferences which result from pooling when the decision to pool, or not to pool, is based on a preliminary test of significance. It was shown that in those estimation problems where it is applicable the generalized procedure includes the preliminary testing procedure as a special case. The investigation of the effectiveness of the generalized pooling procedure in reducing the disturbances resulting from the preliminary testing procedure was confined to comparing the biases and mean square deviations of the estimators based on the two procedures when both are applied in a particular type of problem.

The first problem considered was that of pooling the means of two independent random samples of the same size drawn from two normal populations which have a known common variance, the object being to obtain an estimator for the mean, μ_1, of one of the populations. The pooled estimator may have a smaller variance about μ_1, than the unbiased "never pool" statistics, $\bar{X}_1$, the mean of the sample from the population concerned. The generalized or weighting procedure resulted in the estimator $W_O(t)$ when the weighting function which determines the weights to be assigned to each of the sample means was taken to be $t^2/(1 + t^2)$. The estimator SP(t) was obtained from the preliminary testing procedure. The mean square deviations and biases were derived for both estimators and the efficiency of each relative to $\bar{X}_1$ as a function of the nuisance parameter, γ, was calculated for various values of γ. It was found that if the critical region of the preliminary test is selected so that $W_O(t)$ and SP(t) have the same efficiency

[1]Doctoral thesis no. 1547, submitted June 3, 1954. Chairman of Committee, T. A. Bancroft, Department of Statistics.

[2]B.S., Bethany College, Bethany, West Virginia, 1947. M.S., West Virginia University, Morgantown, W.Va., 1948. Assistant Professor. Cooperator, Industrial Science Research Institute.

when γ is equal to zero the weighting procedure results in a sizeable reduction in the maximum possible loss of efficiency. It was found that the effective difference was larger for $W_0(t)$ than for SP(t). The effective difference was defined to be the largest value of $|\gamma|$ such that for all smaller $|\gamma|$ a gain in efficiency results. When the biases were compared it was found that for values of γ less than approximately 1.8 the bias of $W_0(t)$ is slightly less than that of SP(t) but that for larger values of $|\gamma|$ the bias is smaller for SP(t).

The equations derived for the mean square deviation and bias were generalized to include the pooling of independent normal estimators with different known variance and, in particular, the mean square deviation was derived for the case of pooling sample means when the variances of the means are known but different because of unequal population variances, different sample sizes, or both. It was found that if the ratio of the variances of the means, V_1/V_2, is greater than one, the efficiency will be greater than that obtained for the special case, $V_1/V_2 = 1$, for all $|\gamma|$ less than the effective difference, but for all $|\gamma|$ greater than the effective difference the efficiency will be less than when $V_1/V_2 = 1$.

An admissible class of weighting functions was defined and three criteria, unbiasedness, uniformly minimum variances, and overall efficiency, were considered for selecting a "best" weighting function. Theorems were stated and proved which showed that, (1) the only unbiased weighting function is $\phi(t) = 1$, (2) no uniformly minimum variance weighting function exists, and (3) the weighting function with the greatest overall efficiency is $\phi(t) = 1$ which yields the "never pool" estimator.

A two-parameter family of weighting functions was defined and the mean square deviation of the weighting procedure based on this family was derived. The efficiency relative to $\overline{X}_1$ was calculated for various values of γ and for various values of a and b for the case of equal means with known common variance. The results were compared with those obtained by using $\phi_0(t) = t^2/(1 + t^2)$ for the weighting function. It was found that the effective difference can be increased by decreasing b and adjusting a to give the desired efficiency when γ is zero. This increase in effective difference, however, was found to be accompanied by an increase in the range of $|\gamma|$ for which large losses of efficiency may occur. This suggests that in selecting a weighting function a compromise is required.

The pooling of two transformed correlation coefficients in order to estimate one of the population correlation coefficients was used to illustrate the application of the generalized procedure. The pooling procedure appropriate to this problem was outlined and was illustrated by means of a numerical example.

FARM RENTAL PRACTICES AND PROBLEMS IN THE MIDWEST[1]

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Department of Economics and Sociology

The basic purpose in this study was to develop a set of principles to be applied in dealing with the questions and problems raised by landlords and tenants concerning content of leases and effective leasing arrangements. Data were obtained by a mail questionnaire from tenants in 46 economic areas in Indiana, Iowa, Kansas, Minnesota, Nebraska, South Dakota, and Wisconsin. The seven Agricultural Experiment Stations joined with the Bureau of Agricultural Economics and the Farm Foundation in a cooperative regional research project under the auspices of the North Central Land Tenure Research Committee.

Theory of production economics provides the framework within which leasing practices are analyzed in this study. Production theory specifies the conditions under which income for the firm is a maximum. These conditions are the same for any firm. They are the Hicksian conditions for equilibrium of the firm, specifying the factor-factor and the product-product relations, when capital is limited as is usually the case with

[1]Doctoral thesis no. 1525, submitted May 6, 1954. Chairman of Committee, John F. Timmons, Department of Economics and Sociology.

[2]B.S., Montana State College, Bozeman, Mont., 1933. M.S., University of Wisconsin, Madison, Wisc., 1936. Resident Collaborator U.S.D.A., Agricultural Experiment Station.

farm firms. In addition, four incentive conditions are required within the lease to encourage efficient use of resources and prevent income transfers between resource owners in the tenant operated firm.

The study analyzes leases to determine whether the following four inecntive conditions are included:

1. The share of the factor of variable input must be the same as the share of output of product obtained from it.
2. The shares of all products must be the same.
3. Each resource owner in the firm must receive the full share of the product earned by each unit of resource he contributes.
4. Each resource owner in the firm must have opportunity to receive return on investment made in one production period but not forthcoming until a subsequent period.

The analysis assumes that the function of the lease is to (1) provide a basis for combining resources in production, and (2) distribute income to resource owners within the firm. Furthermore, plans are made and executed for given production periods, usually one year. Some of the resources are fixed for the given period. Variable resources are added to fixed resources in such kinds and amounts as to equate the returns on the final units of the variable in each of its uses. Adjustments are made between production periods in the fixed resources so that in the long run all resources are variable.

Few current leases contain all of the incentive conditions. Each of the conditions must be present in each lease. Otherwise there is incentive for the operator to combine resources at other than the highest profit combination for the total resources contributed to the firm by the landlord and tenant, or there is an income transfer. Assuming that tenants react to the incentive conditions, it follows that current leases encourage misallocation of resources.

The balance of the study deals with selected characteristics of leases, of landlords, and of tenants by making comparisons of distributions of two characteristics at a time, by economic areas. For example, length of lease was compared with type of lease, to ascertain if there is significant difference between length of leases for the various types of lease. In each instance the given item or category was calculated as a percentage of the total number of respondents replying to the two items. Tests of significance for the differences between proportions were made for each set of items.

Although there are numerous differences of significance between given items in current leasing practice, the lack of variation within leases and within areas stands out more than does variation. This suggests that current leases cannot match the variations in farms and the differences between desires and abilities of tenants and landlords. The lack of variation in leases is strong evidence of need for adjustment in leasing practice. Among the more important of these adjustments is that of getting away from standardized fractional shares of crops and of expenses. The share to be paid as rental is a problem for solution on the individual farm, through careful analysis, and is not a "given" proposition to which other items are adjusted. Circumstances differ from farm to farm, tenant to tenant, and landlord to landlord. A set of economic principles that can be applied to any given situation by the parties themselves is needed as the basis for decisions on the many details that are matters of judgment, opinions or outlook, and often also depend upon the alternative opportunities available to both parties.

TERMINAL AMINO ACID RESIDUES APPEARING DURING THE PROTEOLYSIS OF LYSOXYME[1]

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Food Technology Administrative Committee

By determining the terminal amino acid residues appearing during the proteolysis of lysozyme, information was sought regarding:

1. The course of the proteolysis of lysozyme.
2. The preference of the enzymes under study for the peptide linkages in lysozyme.
3. Some of the amino acid sequences in lysozyme.
4. The applicability of the quantitative aminoid sequence method to proteolytic studies.

Termini of the peptide chains, formed during the hydrolysis of lysozyme by chymotrypsin, trypsin, papain, and pepsin, were determined at intervals by a subtractive procedure. At the end of 0, 24, 48, 120, and 240 hours, aliquots were removed from the proteolyzates. The initial samples were completely hydrolyzed with acid, and the amino acids were determined microbiologically. These assay values constituted the compositional values for lysozyme.

In order to determine the aminoid terminal residues, the aliquots were treated with phenylisothiocyanate in aqueous pyridine. Subsequent removal of reagents and acid hydrolysis liberated the constituent amino acids, with the exception of the aminoid terminal ones. The latter were converted into phenylthiohydantoins, many of which have been shown not to be assimilable by the amino acid assay microorganisms under the conditions of assay. The differences between the compositional values and assay values, obtained on the aminoid terminally blocked samples, furnished quantitative figures for the extent of cleavage of peptide bonds involving the aminoid linkage of each amino acid.

A similar approach was used for determining amino acid residues possessing free alpha-carboxyl residues. Treatment of aliquots of the proteolyzates with ammonium thiocyanate in acetic anhydrideacetic acid, evaporation, and subsequent acid hydrolysis lead to the formation of free amino acids and the thiohydantoins of the carboxoid terminal amino residues. Microbiological utilization of these thiohydantoins by the assay organisms, under the particular conditions employed, ranged from 0 to 35 per cent for a limited number tested. Therefore, it was necessary to use a range for a quantitative evaluation of the extent of hydrolysis of bonds involving the alpha-carboxyl groups of each amino acid. This range was from 1.0 to 1.5 times the difference between the compositional values and the values obtained on the carboxoid-terminally blocked samples.

Using these procedures, it was found that chymotrypsin, at an initial pH of 8.5, hydrolyzed both aminoid and carboxoid linkages of arginine. On the average, only one out of the seven aminoid linkages of isoleucine and two to three of the six carboxoid linkages of leucine in a molecule of lysozyme were cleaved by this enzyme. In 240 hours, an average of two residues of lysine were hydrolyzed at their aminoid bond, and one was hydrolyzed at its carboxoid linkage. Likewise, chymotrypsin cleaved two to three carboxoid bonds of phenylalanine and tyrosine and probably one of methionine. An average of approximately five linkages involving the aminoid group of serine, two to three involving the carboxoid group of this amino acid, two involving the aminoid group of valine, and one involving the carboxoid group of the latter, also, were hydrolyzed. With the exception of alanine, cystine, and tryptophan, which were not determined, little or not hydrolysis of bonds of the other amino acids by chymotrypsin was apparent.

Similar calculations for the proteolyses by papain showed that, at initial pH values of 5.0, 7.5, and 8.5, an average of one aminoid bond of lysine, one carboxoid bond of lysine, three aminoid bonds of arginine, and two to three carboxoid bonds of arginine were hydrolyzed. As the pH was increased, a greater number of both aminoid and carboxoid bonds of serine were cleaved. There was little or no apparent hydrolysis of linkages of the other amino acid residues. However, assays were not made for alanine, cystine, and tryptophan.

[1]Doctoral thesis no. 1443, submitted July 17, 1953. Chairman of Committee, Sidney Fox, Department of Chemistry.

[2]B.S., Iowa State College, Ames, Iowa, 1937. M.S., Ibid., 1951. Associate, Institute for Atomic Research.

The action of trypsin appeared to be very similar to that of papain. On the average about one aminoid bond and one carboxoid bond of lysine were hydrolyzed, two to three aminoid linkages and two to three carboxoid linkages of arginine were cleaved, and about two serine aminoid and one serine carboxoid linkages per molecule of lysozyme were hydrolyzed in 240 hours.

Lysozyme showed considerable resistance to hydrolysis by pepsin at pH 4. No linkages of phenylalanine or tyrosine were hydrolyzed. An average of two aminoid linkages of arginine, two to three carboxoid linkages of arginine, one aminoid linkage of isoleucine and two aminoid linkages of serine were cleaved.

It appeared that the sequence of amino acid residues in the lysozyme molecule and, possibly, the rigidity of the molecule, due to cross linkages of cystine, were contributing largely to the preferences of the four enzymes for particular linkages. The facts that all "preferred" linkages, as found for synthetic peptides or derivatives, are not hydrolyzed and that each of the four enzymes attack bonds of the same amino acids lead to this view.

PHYTOTOXICITY OF 2,4-DICHLOROPHENOXYETHYL SULFATE AND ITS DERIVATIVES[1]

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The solubility of 2,4-dichlorophenoxyethyl sulfate, (SES) in water and its lack of toxicity until acted upon by soil bacteria make this chemical a potentially valuable weed control agent. This investigation was a study of the relations of SES to its probable end-products, 2,4-dichlorophenoxyethanol, (2,4-DE), and 2,4-dichlorophenoxyacetic acid, (2,4-D).

Phytotoxicities of SES, 2,4-DE and 2,4-D were compared by growth response to foliage applications on soybeans, to root immersion in solutions of these chemicals, and by growth response of cucumber seedlings growing in treated soil. Respiration of corn germinated in solutions of the chemicals was also used as an index of toxicity.

SES itself was not toxic in foliage or solution culture tests, but was converted to a toxic compound in nonsterile soil, presumably by hydrolysis of SES to 2,4-DE, and possibly by subsequent oxidation of 2,4-DE to 2,4-D. No activation occurred in sterile soil in the range of soil pH from 5.1 to 7.8. Very low soil moisture level limited this conversion, which proceeded rapidly in moist soils above freezing temperatures. Catalysis of conversion of SES by 2,4-DE, 2,4-D or mineral ions in sterile soil was not observed.

2,4-D was 10 to 100 times as toxic as 2,4-DE in foliage applications, and approximately equal in soil applications. In exposures of roots to solutions of these two chemicals, 2,4-DE was more toxic than 2,4-D, and combinations of the two were more toxic than either one alone. Furthermore, the toxicity of 2,4-D, but not of 2,4-DE, was greater as the pH of the solution was lowered; presumably because of reduced dissociation and increased absorption of the 2,4-D molecules, while the nonionic 2,4-DE was not affected.

Both 2,4-DE and 2,4-D caused initial increases in respiration of germinating corn, followed by a reduction to normal or subnormal levels.

In studies of the movement of the chemicals through the soil under the influence of leaching, SES was usually converted to an active compound before appreciable leaching occurred. The leaching of all three of the chemicals was related to the physical characteristics of the soil, but in general neither 2,4-DE nor 2,4-D leached appreciably under the influence of 1/4 inch of surface water application.

The results indicate that the herbicidal effect of field applications of SES may be limited by soil moisture conditions at the time of, and following, treatment. Soil temperature, soil type, rainfall and treatment concentration effects were of little import-

[1]Doctoral thesis no. 1564, submitted June 8, 1954. Chairman of Committee, W.E. Loomis, Department of Botany and Plant Pathology.

[2]B.S., Rutgers University, New Brunswick, N.J., 1951. M.S., Ibid., 1952. Graduate Assistant, Agricultural Experiment Station.

ance in the rate of conversion of SES, and are not considered to be seriously limiting factors in the phytotoxicity of SES. The pH of the soil solution may have an influence on the phytotoxicity of these chemicals.

THE CRYSTAL STRUCTURE OF TWO IODINE-CONTAINING COMPOUNDS[1]

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Part I. Structure of the Cyclohexaamylose-iodine complex.

Iodine reacts with cyclohexaamylose (Schardinger's α-dextrin) in aqueous solution to form an iodide-free crystalline complex, $(C_6H_{10}O_5)_6.I_2 \cdot 12H_2O$. The crystal was found tobe orthorhombic, space group D_2^4--$P2_12_12_1$, with lattice constants a_o = 14.38Å, b_o = 36.07Å, c_o = 9.43Å, requiring four molecules per unit cell.

From the pleochroism of the crystal viewed along each crystal axis, it was concluded that the iodine molecule axis is parallel to the (100) plane and incluned about 45° to the y axis.

Complete three-dimensional data were obtained using Weissenberg and precession cameras. The iodine parameters were determined from two- and three-dimensional Patterson plots and checked by Fourier projection.

The structure which best accounted for the data was a torus-like arrangement of the cyclic carbohydrate molecule, coaxial with each iodine molecule. Consideration of the possible packing arrangements of the complex in the crystal structure and the results of a complete three-dimensional Patterson, as well as measurements of scale models of the complex, lead to a diameter of the torus of approximately 13.0Å and a thickness of 6.7Å.

Attempts to determine more exactly the arrangement of carbon and oxygen atoms in the crystal by means of the isomorphous technique and the Fourier transform method were not successful.

Part II. The structure of tetramethylammonium enneaiodide.

A saturated alcohol solution of $N(CH_3)_4I$ reacts with an excess of I_2 to form dark green, nearly black, monoclinic needles with lattice constants a_o = 11.60Å, b_o = 15.10Å, c_o = 13.18Å, and β = 95°25'. The space group is $P2_1/n$ and contains four molecules of $N(CH_3)_4I_9$ per unit cell.

Complete three-dimensional data were obtained using Weissenberg and precession cameras. Coincidences on all Patterson projections made interpretation so difficult as to prevent determination of the phases of the structure factors. The signs of the structure factors were obtained by methods of inequalities.

Fourier synthesis of four planes of data and refinement of the data by difference synthesis indicate that the enneaiodide structure consists of iodine molecules packed with the cation and a pentaiodide ion. The structure may be best described as a honeycomb arrangement of I_2 molecules whose voids accommodate the positive ions which in turn separate planes of V-shaped pentaiodide ions.

The apex angle of the V is 86.5°. The arms of the V are linear within approximately 7 degrees. The iodine-iodine bond distances are 317Å and 2.90Å in one arm and 2.91Å and 3.24Å in the other. Interaction of the I_2 molecules with the atoms of the pentaiodide ion is appreciable. The I_5^- ions of this structure are not as well defined as in the pentaiodide structure of Hach and Rundle.

Interpretation of the nature of the bonding does not require the use of d-orbitals above the valence shell as in ICl_2^- and ICl_4^-. The bond distances are considerably longer than would be expected for hybrid bonds involving the d-orbital. The distances in the pentaiodide ion of this structure are appreciably greater than I_2, and, in addition, two different distances occur, just as was observed in I_2^- and I_5^- ions.

The structure provides no evidence for believing that either the heptaiodide or enneaiodide constitutes the upper limits of the polyiodides.

[1]Doctoral thesis no. 1490, submitted December 14, 1953. Chairman of Committee, Dexter French, Department of Chemistry.

[2]B.S., Tufts College, Medford, Massachusetts, 1949. M.S., Iowa State College, Ames, Iowa, 1952. Graduate Assistant, Industrial Science Research Institute.

SOLVENT EXTRACTION OF COTTONSEED[1]

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An investigation was undertaken to study the extraction of cottonseed oil by trichloroethylene in a counter-current, continuous, extraction unit and to study the effects of the operating variables on the quality of the products produced and the efficiency of oil extraction. A pilot plant extraction unit, similar in design to the commercial soybean processing unit developed at Iowa State College and bow being manufactured by the Crown Iron Works, Minneapolis, Minnesota, was designed and built to enable this investigation to be carried out with minimum amounts of cottonseed and solvent. This extractor consisted of a 2-inch diameter, continuous loop conduit through which a special Redlar type chain conveyor carried the flaked cottonseed meats. The capacity of the extraction unit could be varied from 4.75 to 13.5 pounds per hour of cottonseed flakes by changing the speed of the conveyor chain. The products obtained from processing cottonseed are an edible oil used primarily in production of vegetable shortenings and oleomargarine, and a high protein content residue used as a supplement in livestock rations. Due to a toxic pigment of cottonseed, gossypol, the residue, or meal, must be given special treatment before it is fed to livestock.

Pilot plant operations yielded data which indicated that a prime crude oil and a meal high in protein and low in free gossypol can be produced in this type of extraction unit with trichloroethylene as a solvent. Since most of the free gossypol contained in the flaked cottonseed is effectively destroyed during the extraction process, the meal can be desolventized at low temperatures which results in high protein solubility of the finished meal. Since certain batches of trichloroethylene extracted soybean meal have been found to be toxic to cattle, it is possible that the same may be true for cottonseed meal, and its feeding to livestock is not recommended until it can be properly evaluated.

The operating variables considered were extraction time, meat diameter, flake thickness, extraction temperature, oil, concentration in the extracting solvent of miscells concentration, moisture content of the flakes, and degree of heating the meats. Mathematical relations were developed which express the individual effects of the first four listed variables on the per cent of extractable material remaining in the processed cottonseed flakes, or the residual extractables. By expressing the miscella concentration in terms of kinematic viscosity, an equation was developed which gives the relation of residual extractables to kinematic viscosity and extraction temperature. This relation is

$$R = 7.16\, e^{(7.15\,\mu/\rho\, -\, 0.0117\,T)}$$

where (R) is per cent residual extractables; (μ/ρ) is kinematic viscosity, ft.^{2}/hr.; and (T) is extraction temperature, °F. The value of the constant in this equation, 7.16, will vary with changes in the extraction variables other than miscella concentration and extraction temperature. It was found that the relation of these variables and this constant could be expressed as the product of the effects of the individual variables. Therefore, by combining this equation with the equations for the effects of extraction time, flake thickness, and meat diameter the following equation was developed:

$$R = 2.60 \times 10^4 \frac{b^{\blacksquare}}{D_m \theta^{0.955}}\, e^{(7.15\,\mu/\rho\, -\, 0.0117\,T)}$$

where (b) is flake thickness, ft.; (D_m) is meat diameter, ft.; and (θ) is extraction time, hours.

It was found that there is no apparent relation between the data obtained in counter-current extractions and static-bed rate extractions. The fact that the miscella concentration for the rate extractions was very nearly zero at all times and varied from zero to approximately 25 per cent during the counter-current extractions is the probable explanation for this lack of correspondence.

A cost estimate for a proposed 50 tons per day cottonseed extraction plant indicated

[1]Doctoral thesis no. 1448, submitted July 16, 1953. Chairman of Committee, L. K. Arnold, Department of Chemical Engineering.

[2]B.S., University of Minnesota, Minneapolis, Minn., 1945.
Graduate Assistant, Engineering Experiment Station.

a processing cost of $97.07 per ton of cottonseed processed. The return on an estimated total investment of $336,000 would be approximately 29.5 per cent, when processing prime cottonseed.

EFFECT OF SEVERAL PROCESS CONDITIONS IN QUICK-CURING OF NORMAL SUPERPHOSPHATE[1]

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A quick-curing process for normal superphosphate previously developed at Iowa State College consists of acidulating phosphate rock, ground to approximately 60 per cent -200 mesh, with 55 per cent sulfuric acid, in the proportions of 1.8 pounds of 100 per cent sulfuric acid per pound of P_2O_5. The material is denned only long enough to allow the formation of a firm block, easily disintegrated without pasting or balling. The shredded material is fed to a Roto-Louver dryer. Previous laboratory and pilot plant studies have given a maximum of 95 per cent P_2O_5 conversion, whereas storage curing in a current industrial process results in 97 to 99 per cent conversion.

This study was undertaken to determine the effect of certain process variables on the available P_2O_5 content and conversion of the product, so that operating conditions for the process may be chosen to result in a product more nearly the equal in conversion of that of the storage process. The variables under consideration were (1) drier inlet air temperature, (2) rock particle size, and (3) certain wetting agents that are stable in the concentration of sulfuric acid used in acidulating the phosphate rock.

The effect of inlet air temperature between 500°F and 1000°F was studied. Particle size and structure of the product changed markedly with increasing inlet air temperature. The particle size decreased from greater than 1/2 inch in diameter to 75 per cent +20 mesh. A hard impervious surface coating disappeared with increasing temperature, at 750°F, and an open pore structure appeared on the surface. This change in structure was associated with the occurrence of a maximum product temperature, for products of the same moisture content, and maximum conversion at any moisture content. The maximum conversion occurred at 650°F for 3 per cent moisture in the product. An increase in drying rate resulted from increasing inlet air temperature.

The effect of rock particle size was evaluated in a series of five runs with rock that varied in size from a commercial grind of 60 per cent -200 mesh down to one having a particle size of between 20 and 30 microns. Rock of 30 to 40 micron maximum size gave the highest conversion at 6 per cent moisture on the same day it was dried, 97 per cent. The three finest sizes, 4 per cent +325 mesh, 30 to 40 microns, and 20 to 30 microns, did not go through a fluid stage during acidulation, perhaps explaining why the finest grind did not result in the highest conversion. After three days storage at 6 per cent moisture, the conversions of the products were in the order of the rock particle size, varying from 99 per cent for the finest to 92 per cent for the coarsest. All rocks resulted in the same maximum conversion of 99 per cent at 14 per cent moisture.

Thirteen wetting agents were tested for their effect on conversion and available P_2O_5 content. Alrose Amine C improved conversion from 1 to 2 per cent over the control runs without a wetting agent. All of the wetting agents improved the physical qualities of the superphosphate before drying.

When Alrose Amine C was used, denning at 176°F for 5 or 12 hours resulted in no difference in conversion. Denning for 22 hours at room temperature resulted in the highest conversion of any conditions studied, and the lowest available P_2O_5 content. This conversion, 96 per cent, was 4.5 per cent greater than that resulting from a 12 hour denning at the same temperature, and 2 per cent higher than with the higher temperature denning. The highest available P_2O_5 content occurred as a result of the high temperature denning. Use of an increased amount of wetting agent caused a slight suppression of conversion. Higher inlet air temperature caused a slightly higher conversion, but the same available P_2O_5 content.

[1]Doctoral thesis no. 1554, submitted June 4, 1954. Chairman of Committee, G. L. Bridger, Department of Chemical Engineering.

[2]B.A.Sc., University of Toronto, Canada, 1945. Graduate Assistant, Engineering Experiment Station.

A parallel series of control runs denned under the same conditions resulted in the same relation with respect to denning time and temperature. However, in each instance the conversion was from 1 to 1.5 per cent lower than the corresponding run with a wetting agent. The available P_2O_5 contents were in each case the same or slightly higher than when the wetting agent was used.

The choice of inlet air temperature and rock particle size, and the decision as to whether to use a wetting agent must be based on a cost analysis for each manufacturing plant.

ADAPTATION OF ECONOMIC PRODUCTION LOGIC TO FEED UTILIZATION BY LIVESTOCK[1]

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The objectives of this study were to indicate (1) the information needed to attain maximum economic efficiency in livestock feeding, (2) the form of data needed in solving production economics problems, (3) the methods of adapting available data to economic problems in lieu of more satisfactory information and (4) the hypotheses and models relevant to future feed utilization studies.

Production economics theory calls for production functions from which marginal substitution rates between feeds in any combination and at any output level may be derived. These functions are not available from livestock feeding experiments. The physiological background of animal digestive systems were reviewed. Effects of digestive systems on the shape or form of animal production functions were illustrated. The necessity of a ration for maintenance when the animal is idle was illustrated in relation to substitution rates. The adaptations in theory necessary because of the limited stomach capacity of the animal were explained. The effects of time were also considered, and alternative methods of incorporating it into the production functions were suggested. The use of production functions in choosing the least cost ration was explained. Similarly, methods of choosing the most profitable grades or quality of product were explained. An empirical example of the average, least-cost ration for a period of 19 years was presented. Margins were shown to be as important as the least-cost ration in maximizing profits from livestock feeder enterprises.

Suggested mathematical models available for use as production functions include the Cobb-Douglas production function, the quadratic function and the exponential function. Characteristics of these functions were discussed in terms of their economic implications and their approximation of actual conditions of production. The Cobb-Douglas was indicated as desirable from the computational standpoint.

Alternative means of obtaining the necessary data to estimate empirical production functions include direct experimentation and use of past experiments which were conducted for other purposes. For future experiments, the use of fixed proportion rations with limited feeding and full feeding were recommended. Although limitations of past experimental data were shown, it was also concluded that useful information could be derived from this source.

As an example, empirical estimates of iso-product contours for yearling steers were derived from records of past feeding experiments. Feed prices were assumed, and the economic implications of diminishing marginal rates of feed substitution were illustrated. Least-cost rations differed for different parts of the feeding period, because the substitution rates were not the same between feeds for the entire feeding period.

Since estimates of the various coefficients of the production functions are based on sample observations, a statistical test of the difference between coefficients estimated for different parts of the feeding period can be made. An example was presented. Difficulties of making the tests when experiments were designed mainly for estimation of coefficients were also explained.

[1]Doctoral thesis no. 1435, submitted July 14, 1953. Chairman of Committee, Earl O. Heady, Department of Economics and Sociology.

[2]B.S., Iowa State College, Ames, Iowa, 1949. Research Associate, Agricultural Experiment Station.

METABOLISM OF CELLULOSE BY MICROORGANISMS OF THE RUMEN[1]

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The chemistry of cellulose digestion by rumen microorganisms was investigated with special reference to the identification of the carbohydrate intermediates formed. The end-products formed during a normal fermentation of cellulose by the rumen bacteria are principally the fatty acids, such as formic, acetic, propionic, and butyric acids. Therefore, in order to study the pathway of cellulose degradation during this type of fermentation the process must be arrested at an appropriate stage so that the various compounds formed during the hydrolysis of cellulose can be identified.

The use of the laboratory rumen, now more commonly termed the artificial rumen, has made possible such an investigation. Strained rumen contents, obtained from the fistulated bovine, were used as the initial inoculum in early experiments. However, in later studies washed rumen bacteria, ruman isolates and cellulolytic cell-free bacterial extracts were also employed as inocula.

Preliminary experimental results showed that when toluene was added to active cellulose-digesting cultures, reducing sugars accumulated in the medium in considerable amount with little or no production of volatile fatty acids. In the absence of such an inhibitor little or no reducing sugars accumulated in the culture medium, and the production of the various end-products was considerable.

Since cellulose is, even in the form of finely ground filter paper as used in these experiments, a solid, insoluble material, contact of the organisms with the cellulose cannot be very uniform. Experiments were therefore conducted employing the soluble cellulose derivatives, namely the carboxymethylcelluloses (CMC) as the cellulosic substrate. In comparing a 24-hour fermentation of ground filter paper, Alphacel (a commercial powdered cellulose product) and CMC-70L by rumen microorganisms in the presence of toluene, it was found that 0.163, 0.179, and 0.268 gm. reducing substances (as glucose) were formed per 100 ml. of media, respectively. The results of these experiments indicated that CMC-70L was a suitable cellulosic substrate for the cellulolytic rumen bacteria.

In order to identify the carbohydrate intermediates formed during the degradation of the cellulose molecule, an efficient inhibitor was required so that a large accumulation of reducing sugars would occur in the culture. Experiments showed that toluene had the ability to inhibit cellulose fermentation by rumen microorganisms at the glucose stage. Therefore, eleven other compounds were tested as to their effectiveness in blocking the metabolic pathway of cellulose digestion by the same bacteria. Of all compounds tested, thymol, chloroform, sodium fluoride, toluene, m-xylene, and iodoacetic acid, in the order of decreasing effectiveness, were found to prevent the further utilization of the reducing sugars by the rumen bacteria to form the volatile fatty acids as end-products. Of these compounds listed, thymol and sodium fluoride were chosen to be used in future experiments to study the identity of the carbohydrate intermediates formed during the degradation of cellulose.

Three general phosphorylating inhibitors, 2-4 dinitrophenol, phloridzin, and sodium azide, were also found to inhibit the cellulose digestion by rumen bacteria at the glucose stage. When phosphorylated sugars were added to the cellulose fermentation media a greater production of volatile fatty acids by the rumen microorganisms resulted, thus indicating that these bacteria can utilize phosphorylated sugars.

The pathway of cellulose digestion by rumen bacteria was studied with special reference to the carbohydrate intermediates formed. Aliquots were withdrawn at hourly intervals from cellulose fermentation cultures having CMC-70L or Alphacel as the cellulosic substrate with sodium fluoride or thymol added as the inhibitor. Glucose and a slight amount of xylose and cellobiose were detected by filter paper chromatography in the fermentation media. Other possible carbohydrate degradation products from the cellulosic substrate, such as cellotriose, cellotetrose, etc. were not detected.

A number of bacterial isolates were cultivated from the rumen of the bovine and tested for their fermentation habits on several carbohydrates. Two cultures were found

[1]Doctoral thesis no. 1426, submitted June 19, 1953. Chairman of Committee, L. A. Underkofler, Department of Chemistry.

[2]B.S.A., University of British Columbia, Canada, 1947. M.S., Ibid., 1949. Graduate Assistant, Agricultural Experiment Station.

that would ferment CMC-70L and Alphacel at an active rate. The morphology, staining characteristics and oxygen requirements of these cultures were studied. Several electron microphotographs were prepared of each isolate.

The inhibitors such as sodium fluoride, thymol and toluene, and the nutrient, fructose-1, 6-diphosphate had the same effect on the action of the two isolates, on CMC-70L as reported for the mixed cultures above. Only glucose was detected as the degradative products of CMC-70L by the cellulolytic action of these cultures.

A number of fermentation experiments were conducted using centrifuged and filtered rumen fluid as inocula. The results showed that the filtered liquid had no cellulolytic activity. The centrifuged liquid possessed slight activity, probably due to the small number of microorganisms remaining in the sample. It was concluded that the cellulolytic enzymes of the rumen microorganisms are not present as such in the rumen fluid, but are associated with the bacterial cells.

A cell-free enzymic extract from rumen organisms capable of degrading cellulose and CMC-70L was prepared by grinding the washed bacterial cells with powdered alumina. The activity of the cell-free cellulolytic enzyme (or enzymes) was maximum at an optimum temperature of 40°C and an optimum pH of 5.5. The enzyme extract was stable at low temperatures but was partially inactivated when allowed to remain at room temperature for 144 hours. The main hydrolytic product resulting from the action of the enzyme on cellulose was shown to be glucose.

HERITABILITY OF ECONOMIC CHARACTERS IN BEEF CATTLE[1]

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The production records of nearly 6000 Hereford calves raised at the U.S. Range Livestock Experiment Station, Miles City, Montana, were analyzed with regard to birth weight, weaning weight, weaning score, yearling weight, and yearling score. The heritabilities, repeatabilities, and genetic correlations for these traits were evaluated. Also the maternal influence and several other identifiable sources of variation, such as sex of calf, age of calf at weaning, and age of dam, were evaluated.

Male calves were 5.6 pounds heavier at birth and 26 pounds heavier at weaning than heifer calves. The sex difference in weaning score was negligible. Age of cow had a marked influence on all traits studied except yearling score. The cow's production with regard to birth weight, weaning weight, and weaning score increased steadily from three to six years of age and then declined.

The maternal environment from conception to birth and from birth to weaning appears to have a large influence on all of the traits studied. The heritability estimates, including the hereditary portion of the maternal influence were 0.42 for birth weight, 0.19 for weaning weight, 0.12 for gain from birth to weaning, 0.16 for weaning score, 0.39 to 0.42 for yearling gain, and 0.26 to 0.29 for yearling score.

The repeatability estimates were 0.26 for birth weight, 0.34 for weaning weight, 0.34 for gain from birth to weaning, 0.22 for weaning score, -0.14 for yearling weight, and -0.08 for yearling score. The biological basis for the negative repeatabilities observed for the yearling records was not clear.

The genetic correlation between birth weight and gain to weaning indicates that many of the same genes affect prenatal and postnatal growth. Genetically, the yearling gain was almost independent of gain from conception to birth and of gain from birth to weaning. The genetic correlations between weaning gain and weaning score and between yearling gain and yearling score were large. The results suggest a large negative genetic correlation between milking ability and the traits weaning gain and score. Milking ability appeared to be positively correlated genetically with yearling gain and with yearling score.

[1]Doctoral thesis no. 1473, submitted December 3, 1953. Chairmen of Committee, L. N. Hazel, Department of Animal Husbandry, and J.W. Gowen, Department of Genetics.

[2]B.S., Montana State College, Bozeman, Mont., 1948. M.S., Iowa State College, Ames, Iowa, 1950. Graduate Assistant, Agricultural Experiment Station.

The consequences of selecting for various traits were examined as to the effect on milking ability. Selecting calves on the basis of weaning gain or score leads to some genetic improvement in milking ability. Selecting cows on the weaning gains and scores of their calves places greater emphasis on milking ability than on growth response. Selecting calves on their weaning gains, where the calves were raised by nurse cows, leads to a loss in milking ability. Selection on yearling gain or score causes a decline in milking ability, even though yearling gain and milking ability are positively correlated genetically. This is due to the negative direct influence of the dam's milking ability on the calf's yearling gain.

QUADRUPOLE-QUADRUPOLE FORCES IN CERIUM METAL[1]

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The specific heat of cerium is calculated using a model which pictures the metal as an array of multipoles super-imposed on a uniform negative charge density. This model gives rise to strong quadrupole-quadrupole interactions between the ions of the crystal. The quadrupole-quadrupole interaction energies are of the same order of magnitude as the term splitting of an ion by a lattice of charges which previous workers have considered as the mechanism responsible for the anomalous specific heat of the rare earth metals.

The six-fold degenerate 4f ground level of Ce is split into a number of components by an electrostatic field. In a charge field with hexagonal symmetry, the ground level is split into three levels, each of which is two-fold degenerate. The splitting in a multipole field depends on the quadrupole-quadrupole forces. If the ions of the several kinds (as determined by the splitting) are distributed at random among the lattice sites, then a partition function may be developed for a canonical ensemble. The derivatives of the partition function correspond to quantities of physical interest; viz., mean number of electrons in a state, total energy, entropy and specific heat. Numerical methods are used to evaluate the above properties.

The exact wave functions of the 4f electrons in a multipole field are not known. Wave functions are approximated for both weak and strong quadrupole-quadrupole couplings and the specific heat is calculated for both cases. The calculated values of the specific heat are in poor agreement with the experimental data of Parkinson, Simon, and Spedding.

It is believed that the difference between the calculated specific heat and the experimental data is due principally to the fact that the various states have been assumed to be randomly distributed among the lattice sites. However, the neglect of exchange forces may be of comparable importance. An attempt to include ordering in the calculations has not proved fruitful except that the study of order indicates that an ordered arrangement of the various kinds of ions is expected at low temperatures. The difference in energy between the random arrangement and the expected ordered arrangement is of the order of magnitude of the temperature at which the anomalous peak occurs. No quantitative conclusions as to the effects of order on the specific heat of cerium can be drawn at this time.

[1]Doctoral thesis no. 1466, submitted December 2, 1953. Chairman of Committee, Joseph M. Keller, Department of Physics.

[2]B.A., New York University, New York City, 1948. Research Assistant, Institute for Atomic Research.

SPRAY DRYING COSTS IN LOW-VOLUME MILK PLANTS[1]

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Dairy plant managers and boards of directors who contemplate installation of a skimmilk spray drying system need reasonably accurate information on the cost-volume relationships involved in spray drying processes if they are to make economic investments. The need for this information has increased recently because of changes in dry milk production and consumption patterns. These changes have resulted in an increased demand for non-fat milk solids for human food. The increased demand has been reflected in a higher price and increased production.

Increased production has necessitated an increase in processing facilities. In many instances the decision to install drying facilities was made without adequate information about cost-volume relationships. This has resulted in inefficient resource allocation in some plants. The objective of this study is to provide information concerning the cost-volume relationships in low-volume spray-drying plants and thereby assist entrepreneurs in investment decisions. The study is based on a budget analysis of four plants with volumes of 938,200, 1,875,600, 2,817,000, and 3,767,500 pounds of powder produced per year. These volumes of powder production correspond to annual butter volumes in plants producing one, two, three, and four 1800 pound churnings per day in the peak season. Several additional cost points were budgeted in order to obtain the minimum cost point for each of three equipment combinations. In this budget analysis, the physical inputs required were determined and prices were attached to these physical inputs.

The analysis indicates that as volume increased, up to a volume of 3,174,700 pounds of powder per year, unit costs decrease quite rapidly. Beyond this volume, costs do not decrease appreciably as volume increases. The processing costs varied from ₡7.64 per hundredweight in a plant producing 938,200 pounds of powder per year to ₡5.08 per hundredweight in a plant producing 3,174,700 pounds per year. At a volume of 3,767,500 pounds of powder per year, a volume increase of 582,800 pounds per year, processing costs only decrease ₡.04 per hundredweight. Therefore, for all practical purposes, the low cost point is achieved at a volume of 3,174,700 pounds per year, In addition to unit processing costs being reduced, the distribution of costs change as volume increases. The variable costs become relatively more important and the fixed costs relatively less important as volume increases.

The findings of this analysis provide information which may be used as an aid in comparing the relative profitability of each alternative operation available to the plant. In addition to providing information for comparison of the relative profitability of several alternatives, the costs derived in this study provide cost data for producer payment under a "component" pricing plan.

The general conclusions of this analysis indicate that:

1. Processing costs decrease as volume increases, within the range of this study. Processing costs decrease rather rapidly in the lower portion of the volume range, from ₡7.64 per hundredweight at a volume of 938,200 pounds per year to ₡5.08 per hundredweight at a volume of 3,174,700 pounds per year. Beyond this volume, however, costs do not decrease appreciably as volume increases.
2. Skimmilk drying equipment is not utilized most efficiently at volumes of 938,200, 1,875,600, and 2,817,600 pounds of powder produced per year. When volume exceeds three million pounds per year resources are used efficiently and the lowest processing costs are obtained.

[1]Doctoral thesis no. 1543, submitted June 2, 1954. Chairman of Committee, Geoffrey Shepherd, Department of Economics and Sociology.

[2]B.S., Southern Illinois University, Carbondale, Ill., 1951. M.S., Iowa State College, Ames, Iowa, 1952. Research Associate, Agricultural Experiment Station.

BACTERIAL METABOLISM OF ARGININE[1]

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Washed cells of Streptococcus lactis liberate one equivalent of ornithine and carbon dioxide and two equivalents of ammonia from arginine. Citrulline is not metabolized. The stoichiometry of arginine degradation by cell-free extracts is similar. In addition, citrulline is converted to equimolar amounts of ornithine, carbon dioxide, and ammonia. It has been concluded that citrulline is an intermediate in the degradation of arginine.

The conversion of arginine to citrulline is catalyzed by extracts which have been dialyzed against distilled water. The optimum pH for the reaction extends from pH 5.4 to pH 5.8. Maximum rates occur in phosphate or acetate buffer. Phthalate and maleate buffer are somewhat inhibitory. Arsenite is a potent inhibitor of the reaction. Azide, hydroxylamine, semicarbazide, and fluoride are without effect. No coenzyme or cofactor requirements have been demonstrated. The reaction goes to completion and is useful for the specific and quantitative degradation of arginine in the presence of guanido and carbamido compounds and amino acids. The amount of ammonia produced is used as a measure of the arginine present.

The enzyme system which catalyzes the conversion of citrulline to ornithine is present in dialyzed extracts but requires the addition of adenosine diphosphate, Mg^{++} and orthophosphate for activity. Adenosine diphosphate may be replaced by adenosine monophosphate or adenosine triphosphate. The effectiveness of the latter is due to hydrolytic enzymes which form adenosine diphosphate. In the presence of arsenate, the enzyme system has no coenzyme or cofactor requirements. The pH optimum, both in phosphate and arsenate, is pH 6.2-6.3. The rate of reaction of the arsenate system is considerably greater than that of the phosphate system. Phosphate is inhibitory to the arsenate system. Fluoride is markedly inhibitory in the presence of either phosphate or arsenate.

The conversion of citrulline to ornithine leads to the esterification of orthophosphate. Adenosine diphosphate and possibly adenosine monophosphate function is phosphate acceptors. The role of the latter is not clear inasmuch as adenylate kinase has been found in the extracts. The synthesis of energy-rich phosphate bonds can best be demonstrated by addition of purified hexokinase and glucose to the reaction mixture. The amount of glucose-6-phosphate formed is used as a measure of the adenosine triphosphate synthesized. A complete chemical balance indicates that the conversion of citrulline to ornithine by cell-free extracts of Streptococcus lactis occurs according to the following equation:

$$R\text{-}NH\text{-}CONH_2 + H_3PO_4 + ADP \xrightleftharpoons{Mg^{++}} R\text{-}NH_2 + CO_2 + NH_3 + ATP$$
$$(R: \ -CH_2\text{-}CH_2\text{-}CH_2\text{-}CHNH_2\text{-}COOH)$$

In a time-course study of the reaction it was found that the ratio NH_3 (or CO_2):P is nearly one and remains essentially constant with time. This is interpreted to indicate that the carbamyl group (NH_2-CO-) of citrulline is split-off by a phosphoclastic type of reaction. The products of the phosphoclastic reaction are released from the enzyme surface simultaneously with the transfer of high-energy phosphate to a suitable acceptor.

In the light of information presently available, the mechanism of the reaction may be depicted as follows:

1.

$$R\text{-}NH\text{-}CONH_2 + H_3PO_4 + Ez \longleftrightarrow R\text{-}NH_2 + Ez\text{-}C(=NH)\text{-}O\text{-}P(=O)\text{-}(OH)_2$$

(Phosphorylase)

[1]Doctoral thesis no. 1472, submitted November 20, 1953. Chairman of Committee, C. H. Werkman, Department of Bacteriology.

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2. $$\text{Ez-C(=O)-O-P(=NH)-(OH)}_2 + \text{ADP} \xrightleftharpoons[\text{HOH}]{\text{Mg}^{++}} \text{Ez} + \text{CO}_2 + \text{NH}_3 + \text{ATP}$$

(Phosphokinase)

Reaction 1 represents the phosphoclastic split of citrulline giving ornithine and a phosphorylated carbamic acid which remains attached to the enzyme surface (Ez). The phosphorylated carbamic acid contains phosphate at the high energy level. Reaction 2 represents the transfer of high energy phosphate to adenosine diphosphate and the hydrolytic decomposition of carbamic acid. Only Reaction 1 is operative in the presence of arsenate because of the supposed instability of arsenyl carbamic acid. Ornithine and fluoride are inhibitory in the presence of phosphate or arsenate. The site of this inhibition is Reaction 1 according to the proposed mechanism.

The reversibility of the reaction has been demonstrated by use of $C^{14}O_2$ in exchange type of experiments. A net synthesis of citrulline has also been shown. Adenosine triphosphate is required for fixation of $C^{14}O_2$ as well as for synthesis. No involvement of carbamyl-L-glutamic acid has been demonstrated.

It is apparent that the metabolism of citrulline by bacteria is a complex reaction. Until such time as the enzymes involved can be identified and correctly named, it is proposed that the reversible conversion of citrulline to ornithine be known as the citrulline phosphorylase reaction.

STORAGE CHANGES IN PACKAGED MEATS[1]

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An investigation was made of the effects of various packaging materials, lights, gases, and relative humidities on the keeping quality of self-service meat items held at refrigeration temperatures. Keeping time generally was based on occurrence of off-odor or slime formation. These manifestations of spoilage were associated with definite numbers of organisms per sq. cm. of meat surface. Other criteria of spoilage included production of H_2S or CO_2 by microorganisms.

Materials that preserved the bright red color of fresh meat in the early phases of storage permitted most rapid development of microorganisms on the surface of the meat. The time for discoloration varied with wrapping materials used. Fresh beef packaged with materials having low permeability to oxygen exhibited the purple color of reduced myoglobin throughout storage periods as long as 16 days at 4.4°C. Subsequent oxygenation of the pigment with resultant bright red color occurred on exposure of the meat to air.

Of various packaging materials tested, a laminate of aluminum foil and Pliofilm was found to be most effective in retarding spoilage of fresh meats. Owing to its low permeability to gases, this material was well adapted for packaging the CO_2. With all materials employed, keeping time of meat was improved by the incorporation of CO_2 within the atmosphere of the packages. Initial exposure of fresh beef to CO_2 prior to packaging was demonstrated to be of value in prolonging storage life. The level of gas for such exposure was limited by the discoloration that resulted when high concentrations were used.

Improvement in storage life resulting from the use of relatively gas-impermeable films was ascribed to low rates of exchange of gases between the outer atmosphere and the atmosphere in packages; keeping time was greater with heavy gauge Saran films than it was when thinner films of the same type were utilized as wrappers for fresh meat.

[1]Doctoral thesis no. 1461, submitted October 26, 1953. Chairman of Committee, John C. Ayres, Department of Food Technology.

[2]B.S., Cornell University, Ithaca, New York, 1947. M.F.S., Ibid., 1949. Graduate Assistant, Agricultural Experiment Station.

Reduction in temperature and low initial contamination favored extension of keeping time of packaged fresh meats.

When beef was wrapped with MSAT-80 cellophane and with Pliofilm FM-1, holding at low humidity was not a practical means of controlling growth of surface organisms because of accompanying discoloration and dessication. The humidity of storage did not effect changes in beef wrapped with Saran laminated to cellophane. Surface bacterial growth on beef wrapped with polyethylene laminated to cellophane was retarded to some extent at low humidity; discoloration and dehydration of the meat were negligible.

Germicidal ultraviolet light caused inhibition of bacterial growth on fresh beef wrapped with a highly transparent material, but this type of light also produced darkening and dessication of the meat. In addition, ultraviolet radiation effected deterioration of packaging films. Dehydration of meat exposed to germicidal ultraviolet light appeared to be partly responsible for discoloration and for retardation of bacterial development. When fresh beef was displayed under Soft White fluorescent light, little difference was observed in color, reflectance, or bacterial growth at different light intensities.

Spectral reflectance of fresh beef showed a definite trend with regard to color changes; reflectance values decreased as discoloration progressed.

Packaging of cured meats in atmospheres of nitrogen or CO_2 did not prevent fading of color on exposure of the meats to light; however, less discoloration was observed than that resulting from packaging in an atmosphere of air. Color changes of cured meats packaged under vacuum resembled those of similar meats held in CO_2 or in nitrogen.

Storage life of frankfurters packaged with several wrapping materials was increased by high concentrations of CO_2 in the atmosphere of the packages, when storage was carried out at 4.4°C and 7.2°C. The ability of materials to retain the gas was an important consideration; however, the meat did not spoil until some time after CO_2 had been lost from the packages. Keeping time of picnic ham also was extended by the use of CO_2; vacuum packaging produced similar results. Packaging in an atmosphere of nitrogen gave no greater storage life than that resulting from packaging in air.

Reduction of humidity caused pronounced discoloration and desiccation of sliced bologna wrapped with LSAT cellophane. Proliferation of surface organisms was retarded by the use of the cellophane with storage at low humidity. Materials that provided good barriers to transfer of moisture vapor prevented darkening due to dehydration of the meat, but with these films bacterial growth was not appreciably affected by relative humidity of the atmosphere external to packages.

Changes in color of packaged bologna stored under light were determined by a panel of judges and by reflectance measurements. A scoring system based on the ratio of reflectance at 650 mμ to reflectance at 570 mμ was devised for assigning scores to controls. The reflectance ratio decreased as fading of color progressed; however, when appreciable desiccation of the meat occurred, the reflectance ratio was not as closely related to judges' scores as were values for reflectance at wavelengths from 540 to 800 mμ.

Germicidal ultraviolet light caused some reduction in the numbers of bacteria on picnic ham. This type of light produced less discoloration of the lean cured meats than that found when fluorescent lighting was employed, but the fat of picnic ham showed brown discoloration after exposure to ultraviolet radiation.

Color fading of cured meats was more rapid and more advanced at high intensities of fluorescent light than it was when low intensities were used for display of the meats; this relation was observed regardless of packaging materials or methods employed. Intensity of visible light did not affect development of bacteria on cured meats.

TRANSMISSION OF 0-50 KILOVOLT ELECTRONS BY THIN FILMS WITH APPLICATIONS TO BETA-RAY SPECTROSCOPY[1]

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The transmission of electrons by thin films as a function of the incident energy of the electrons was measured using thermal electrons which were accelerated across a known potential difference. The electrons transmitted by the film were detected by a Faraday collector. The extrapolation of the linear portions of the transmission curves to zero transmission gave practical values of energy, E_p, for the films which were shown to correspond to practical ranges of electrons in the films. Good agreement was found with the ranges of electrons in aluminum as given by Schonland (1) whose thinnest film was 0.25 mg/cm^2 in area density. The present author has measured the ranges of electrons in films of area density as low as 0.023 mg/cm^2, which is considerably lower than the area densities reported in previous range-energy measurements.

The theoretical mean ranges as calculated from the average energy-loss formula of Bethe (2) were in reasonably good agreement with the practical ranges measured in this investigation. Most of the films studied were composite films of aluminum and plastic, and range calculations were made for the two separate cases of aluminum and plastic. The experimental data were quite well bracketed by the two extreme calculations. In principle, the mean ranges calculated from theory are different from the experimental ranges defined by the extrapolation process. Furthermore, the effect of scattering at these energies is such that accurate application of the theory is nearly impossible. Nevertheless, for energies less than 40 Kev, the application of Bethe's energy-loss theory to this kind of experiment gives much better predictions of experimental ranges than does the empirical range energy relation of Katz and Penfold (3). In addition, the theoretical range-energy curve has the same direction of curvature as does a curve drawn through the experimental points, whereas the relation of Katz and Penfold has the opposite curvature.

The present author has found that all of his values of E_p fall within 15 per cent of those calculated from the relation, $E_p = 22.2R^{0.6}$, where E_p is in Kev and R is in mg/cm^2. This relation holds between 1.5 Kev and 25 Kev.

Transmission experiments on a 0.012 mg/cm^2 collodion film which was not coated with aluminum indicated that it was essentially a conductor under the conditions of the experiment. Similar measurements on an uncoated 0.3 mg/cm^2 Formvar film resulted in a hysteresis effect indicating a considerable accumulation of charge on the film.

One of the aluminum-coated Formvar films for which the transmission curve had been measured was employed as the window in a G-M counter in a thin-lens beta-ray spectrometer. When the transmission curve for the window was applied to the beta-ray spectrum of a 0.0002 mg/cm^2 source of Pm^{147} on a 0.006 mg/cm^2 collodion backing, an over-correction resulted in the Fermi plot. Multiple scattering calculations estimate that most of this over-correction may well be accounted for by the fact that the counter and Faraday collector subtend different solid angles of collection.

The Fermi plot of C^{14} was found to be linear for energies above 40 Kev. The thinnest source had an effective thickness of about 1.5 mg/cm^2, so that little can be said from this investigation concerning the true shape of the C^{14} Fermi plot below 40 Kev.

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[1]Doctoral thesis no. 1462, submitted November 2, 1953. Chairman of Committee, D. J. Zafferano, Department of Physics.
[2]B.S., Drexel Institute of Technology, Philadelphia, Penn., 1948.
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DIGESTION AND ABSORPTION OF CARBOHYDRATES IN THE YOUNG BOVINE[1]

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Supplementation or replacement of the normal milk diet of the young bovine with more economical sources of energy yielding nutrients is a major field of interest. Corn starch is one of the more readily abundant supplements but investigators have noted that calves, when fed starchy grain feeds as milk substitutes, do not thrive and digestion seems impaired. In previous studies by the author it was also noted that when starch of a grain source entered the gastrointestinal tract without having undergone previous rumen digestion, it appeared in the feces essentially undigested.

It was the object of this present experiment to investigate indirectly by measuring blood reducing sugar levels and directly by digestibility studies the ability of the young bovine to digest starch and related carbohydrates.

Three male calves (two Milking Shorthorns and one Holstein) at approximately three to four months of age were provided with permanent rumen and cecal fistulae. For the following three to four months the animals were prepared for omaso-abomasal feeding by insertion of progressively larger plugs into the fistular openings.

During the period prior to initiation of the experimental regime the animals were fed milk, hay, and concentrates. At the beginning of the experiment hay and concentrates were removed from the diet and the animals were muzzled, were allowed water free choice and were fed the various experimental diets during a series of two-day periods. Between the two-day experimental feeding periods a two-day recovery period was allowed during which whole milk was fed (15 pounds per calf daily). The two-day milk feeding period allowed for recovery from effects of experimental feeding. Milk was selected since it permitted maintenance of the rumen in a non-functional state, thus eliminating any possible interference from rumen ingesta passing down the gastrointestinal tract.

Each of the animals was fed four diets which differed principally in source of carbohydrate. Corn was a major constituent of diet I, but was replaced in diets II, III, and IV by other dietary components. The N.F.E. of the corn in diet I was replaced by an equivalent amount of starch, maltose, and glucose in diets II, III, and IV, respectively.

Mean blood reducing sugar levels (mg. per 100 ml. blood) at 0, 1, 2, 4, 6, 8, and 10 hours, respectively, after omaso-abomasal administration of the experimental diet were 54, 60, 60, 59, 52, 52, and 55 for corn; 54, 59, 60, 55, 56, 58, and 53 for starch; 48, 66, 90, 84, 55, 46, and 49 for maltose; and 52, 82, 108, 108, 84, 56, and 48 for glucose. These data suggest that hydrolysis of starch in the gastrointestinal tract posterior to the rumen is absent or does not proceed at a rate sufficiently great to alter venous blood reducing sugar levels, since only maltose and glucose show definite absorption.

The digestibility studies revealed essentially no glucose or maltose in the samples of cecal ingesta, collected from the cecal fistulae, or in feces. Therefore, the apparent digestibility of glucose and of maltose was essentially 100 per cent. Digestibility of carbohydrate in the corn and starch diets, as determined by the use of an inert reference substance (chromium oxide), varied widely. These observations may be attributed in part to the persistent diarrhetic condition of the animals during omaso-abomasal feeding. The extremely fluid ingesta in the lower portion of the gastrointestinal tract of the scouring animal may have altered the homogeneity of dispersion of the chromium oxide, thus resulting in variable digestibility results. The overall evaluation of the digestion of corn and starch at the cecal and fecal levels indicates low digestibility. Thus, the young bovine apparently is unable to utilize starch (per se or in corn) efficiently without previous digestion in the rumen. The net change in digestibility between the cecum and the point of excretion revealed little change in the corn diet but a positive change appears to take place with the starch diet.

Upon completion of the above study two of the calves (Milking Shorthorns) were anesthetized, their viscera were exteriorized and a 50 per cent glucose solution was injected into isolated portions of the rumen, ileum, jejunum, and cecum. Subsequently, the blood reducing sugar levels increased in the efferent blood from each of the isolated portions studied, the greatest increases resulting from the jejunum.

[1]Doctoral thesis no. 1492, submitted December 14, 1953. Chairman of Committee, N. L. Jacobson, Department of Animal Husbandry.

[2]B.S., University of Wisconsin, Madison, Wisc., 1950. M.S., Iowa State College, Ames, Iowa, 1952. Graduate Assistant, Agricultural Experiment Station.

MECHANISM OF HINDERED SETTLING AND FLUIDIZATION[1]

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A study carried out in these laboratories by Grandjean in 1948-49 and continued by Peterson in 1949-50 on the "hold-up" of solvent droplets in a spray column extractor indicated that both droplet concentration and velocity varied with operating conditions in an apparently unpredictable manner.

The problem thus presented led Dr. B.F. Ruth of these laboratories to develop a correlation for describing the relative motion of fluids and particle aggregates in all its aspects by means of a single general equation. Inasmuch as the fundamental theory involved is most easily tested by observing the porosities achieved in the fluidization of solid spherical particles, together with the corresponding settling rates, the results described in this thesis have been limited to spherical solids. There is, however, no reason to doubt that it is equally applicable to irregularly shaped solids and liquid droplets and further work to support this belief is being continued.

The general correlating equation takes the form

$$k_u = (1 + Z) = K_u \tag{1}$$

where k_u, Z, and K_u represent three dimensionless groups comprising properties of solid and fluid. Explicitly written, K_u becomes

$$K_u = \frac{gD^3(\delta - \rho)\rho}{18\mu^2} \tag{2}$$

in which D is the diameter of a sphere or the spherical diameter of an irregular particle, δ the density of the solid, ρ the density of the fluid, and μ the fluid viscosity.

For the most simple case, that of spheres, small enough to obey Stokes' law, k_u and Z become

$$k_u = \frac{Du\rho}{\varepsilon\mu} \tag{3}$$

$$Z = \frac{2K_e}{\phi'} \tag{4}$$

where ε is the porosity of a particle aggregate (equal to $1 - \gamma$, where γ is the concentration), K_e is a constant having a numerical value of about 2.5, and ϕ' is a concentration function defined as

$$\phi' = \frac{\varepsilon^2}{1 - \varepsilon} \quad \text{or} \quad \frac{(1 - \gamma)^2}{\gamma} \tag{5}$$

As ε approaches unity, or γ approaches zero, ϕ' approaches infinity, and Z approaches zero. As a result, Equation (1) reduces to Stokes' law in the case of a single sphere.

For irregularly shaped particles small enough to obey Stokes' law, k_u and Z become

$$k_u = \frac{Du\rho}{\sqrt{\psi}\varepsilon\mu} \tag{3a}$$

and

$$Z = 2K_e/\psi^{3/2}\phi' \tag{4a}$$

where ψ is the sphericity of an irregularly shaped particle, defined as the ratio of the surface area of a sphere having the same volume as a particle, to the surface area of the particle.

Rearrangement and simplification of Equation (1) with k_u, Z, and K_u explicitly evaluated as given by Equations (3a), (4a), and (2), results in the relation

$$\frac{\varepsilon}{u} = \frac{1}{\sqrt{\psi}V_s} + \left[\frac{2K_e}{(\sqrt{\psi}V_s)\psi^{3/2}}\right]\frac{1}{\phi'} \tag{6}$$

which implies that a plot of porosity divided by sedimentation velocity should be a linear function of the reciprocal of the concentration function as defined by Equation (5), and that the Stokes' law falling velocity $\sqrt{\psi}V_s$ of a single particle may be found as the reciprocal of the intercept on the ε/u axis.

[1]Doctoral thesis no. 1496, submitted December 15, 1953. Chairman of Committee, B. F. Ruth, Department of Chemical Engineering.

[2]B.S., Virginia Polytech. Institute, Blacksburg, Va., 1949. Research Assistant, Institute for Atomic Research.

Data secured in the sedimentation of 48 mesh ground glass spheres in ethylene glycol provide an excellent verification of Equation (6), yielding a value for K_e of about 2.5. It is apparent that when the value of K_e is known from tests carried out on spheres, the sphericity of irregularly shaped particles can be found from the slope of the plot of Equation (6) as

$$\psi = \left[\frac{2K_e}{(\sqrt{\psi}\, V_s)(\text{slope})}\right]^{3/2} \qquad (7)$$

The extension of Equation (1) to the technologically important region of eddying fall is treated by writing k_u and Z as

$$k_u = \frac{Du\rho}{\sqrt{\psi}\,\varepsilon\mu}\ (1 + F_s) \qquad (3b)$$

and

$$Z = \frac{2K_e\ (1 + F_{Ke})}{\psi^{3/2}\,\phi'(1 + F_s)} \qquad (4b)$$

where F_s is a factor representing the ratio of the additional turbulent force resisting the eddying motion of a sphere through a fluid, to the purely viscous force operating when Stokes' law is obeyed. The total force opposing the motion of a single sphere thus becomes $3\pi\mu uD(1 + F_s)$, constituting a modified Stokes' law force. Experimental values of F_s computes directly from data on the falling velocities of single spheres and isometric particles, when plotted against $Du\rho/\sqrt{\psi}\,\mu$, afford a precise empirical correlation of the fall of spheres and particles (in the absence of spin) over a Reynolds' number range extending from 0.01 up to 20,000.

The factor F_{Ke} is similar to the quantity F_s in that it represents the ratio of the additional force communicated to particles on account of turbulent fluid shear in the regions between pairs of particles when a multiple number of them are present, to the force that would be present if flow were viscous. Because the relative motion of fluid and expanded aggregates of particles should resemble the flow of fluid through compact granular media, governed by the Kozeny equation, the form of the equation relating the crowding force to the properties of the aggregate and fluid is postulated to resemble the Kozeny equation. This hypothesis yields the following relation between the buoyant force tending to decrease the volume of an aggregate and the sum of the modified Stokes' law and Kozeny law forces tending to expand it, i.e.,

$$\frac{3\pi\mu uD}{\varepsilon\sqrt{\psi}}\ (1+F_s) + \frac{3\pi\mu uD}{\varepsilon\sqrt{\psi}}\left[\frac{2K_e(1+F_{Ke})}{\psi^{3/2}\ \phi'}\right] = \frac{\pi D^3(\delta - \rho)g}{6} \qquad (8)$$

When this equation is simplified and rearranged to yield the dimensionless groups of Equations (2), (3b), and (4b), Equation (1) results.

Since for spheres the factor F_{Ke} is the only quantity not susceptible of direct experimental measurement, the validity of Equation (8) is seen to depend upon whether or not the factor F_{Ke} can be shown to constitute a unique function of some modified Reynolds' number.

For this purpose numerous experiments were carried out to observe the degree of expansion achieved by aggregates of closely sized spheres at various fluid velocities. In all but a few cases, falling velocities of the same aggregates in quiescent fluid were observed by suddenly interrupting the flow.

Except for small particles settling in a viscous liquid, the velocity of sedimentation was found equal to the fluid velocity during fluidization, and a constant for any given expansion of the bed.

Just as the velocity of fall of a single sphere is considerably affected by the nearness of a bounding wall, so is velocity of sedimentation and fluidization also subject to a wall effect. Because this is not completely eliminated by going to large tube diameters, the evaluation of the factor F_{Ke} is not subject to anywhere near the same precision obtainable for the factor F_s. For this reason no attempt was made to evaluate K_e by itself. Instead, the entire quantity $K_e(1 + F_{Ke})$ was plotted against the modified Reynolds' number

$$N_{Re\ mod} = \frac{Du\rho}{\delta\mu} \qquad (9)$$

Plots showing the variation of $K_e(1 + F_{Ke})$ with the modulus $Du\rho/\gamma\mu$ are shown for spheres varying in size from 0.004 in. to 0.200 in., fluidized in water and ethylene glycol. In columns of sufficiently large diameter, the factor $K_e(1 + F_{Ke})$ has a constant value of about 2.50 throughout the viscous region up to a $Du\rho/\gamma\mu$ of about 3.0. Beyond this point the curve increases with $Du\rho/\gamma\mu$ with a logarithmic slope of about 0.27 for beads up to one mm. in diameter. The plot of $K_c\ (1 + F_{Kc})$ for a compacted bed against $Du\rho/\mu\gamma$ is constant at 5.0 up to a value of about 17 for the Reynolds' modulus, after which it shows a constantly increasing value. For spheres which fluidize above a Reynolds' modulus of 3.0 the plots of $K_e\ (1 + F_{Ke})$ break away from this compacted bed line to give lines parallel to the previously mentioned line of slope 0.27. The exact location of one of these lines for any given expanded bed (the point at which the line intersects the compacted bed line) can be predicted from the buoyant weight of the bed.

Since the primary objective of the present work was to verify the correlation in the technologically important region of eddying fall, only the threshold of the region of viscous fall was attained or investigated. It should be pointed out that the present correlation is not expected to hold very far into the viscous region on account of the increasing importance ot ehe electrokinetic forces developed by the counter-current movement of particle aggregates in liquids. The separation of a particle aggregate from a suspending fluid by means of sedimentation develops an electrostatic potential (known as the Dorn effect), which can become as great as 80 volts in the case of quartz particle settling through toluene. The development of this potential during sedimentation of fine particle aggregates corresponds to a retarding force, which in the absence of gravitational force would cause an electrophoretic migration of particles back towards the region from which they have come at a velocity proportional to the developed potential.

For this reason, the application of Equation (8) to settling in the Stokes' law region requires writing an additional term on the left hand side to represent a retarding electrokinetic force. Since this is not a function of particle size, it becomes increasingly important in the sedimentation of very small particles. A study of this phenomenon is planned as a part of the future work.

HERITABILITY OF PRODUCTIVE CHARACTERS IN DUROC SWINE[1]

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Departments of Animal Husbandry and of Genetics

The main objective of this study was to estimate heritability for litter size and growth rate in swine. Litter size was measured at birth, 63 and 180 days, and growth rate was measured at 63 and 180 days.

The data were obtained from the Duroc herd maintained by the Ralston-Purina Company near St. Louis, Missouri. They consist of 1,079 litters from which 12,185 pigs were farrowed, 8,403 pigs were weaned, and 7,746 pigs reached maturity. All Duroc litters farrowed between 1939 and 1950 were used. The average inbreeding of the dams was 5 per cent and of the litters was 9 per cent. All dams used in the study had a litter at one year of age, and 66 per cent of the dams remained in the herd to have a litter at one and one-half years of age.

The analysis of the variations was within groups in which all the animals were contemporary with respect to year, season, age of dam of litter, and age of grand-dam of litter. Heritability was estimated as twice the regression of offspring on those of female parent. The heritability estimates obtained were as follows:

Number born	.03
Number at 63 days	-.03
Number at 180 days	-.12
Weight at 63 days	.14
Weight at 180 days	.22

[1]Doctoral thesis no. 1477, submitted December 8, 1953. Chairmen of Committee, L. N. Hazel, Department of Animal Husbandry, and John W. Gowen, Department of Genetics.

[2]B.S., West Virginia University, Morgantown, W. Va., 1941. M.S., University of Maryland, College Park, Md., 1942. Graduate Assistant, Agricultural Experiment Station.

Means By Age of Dam

Grouping		Means				
		Numbers			Weight	
Age of dam (In years)	Number of litters	Farrowed	63 days	180 days	63 days	180 days
1.0	412	9.9	7.4	6.7	36.6	173
1.5	270	10.6	7.7	7.1	42.3	188
2.0 & over	397	13.2	8.3	7.8	43.1	193

During the period of this study a definite increase was accomplished in the yearly means for 180-day weight, with smaller and less certain increase in 63-day weight. There was no definite trend in number farrowed, number at 63 days, or number at 180 days. Thus the estimates of heritability are in agreement with the consequences of selection. Repeatability for number born, number weaned, and weaning weight was .18, .11, and .41 , respectively.

Heritability estimates obtained for litter size in this study indicate that the heriditary variation present is of the nonadditive type, but whether its nonadditivity is primarily due to dominance, to epistasis, or to over-dominance is not known.

EFFECT OF TWO CYCLES OF RECURRENT SELECTION FOR COMBINING ABILITY ON YIELD IN AN OPEN-POLLINATED VARIETY OF CORN[1]

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Department of Agronomy

The recurrent selection method is used in modifying combining ability involves the intercrossing of S_1 progenies of S_0 plants selected on the basis of their yield in test crosses. The intercrosses then serve as foundation material for the next cycle of selection. The procedure may be continued for additional cycles as long as sufficient genetic variability is present for effective selection. The use of the system is assumed to permit partial circumvention of certain limitations inherent in breeding methods involving continuous self-pollination. The limitations are those resulting from the large number of genes conditioning yield and other agronomic characters, linkage, and the rapid rate of gene fixation under continuous self-pollination.

The purpose of this study was to determine some of the effects of two cycles of recurrent selection for combining ability in an open-pollinated variety of corn. Three second-cycle synthetic varieties developed under the recurrent selection system and the open-pollinated variety from which they were derived were compared as sources of new lines. A group of advanced generation lines developed under a system of continuous self-pollination in which selection at each generation from S_1 to S_5 was based on test-cross performance were compared with S_1 lines from the second-cycle synthetics. The genetic variability for combining ability was estimated in the synthetic varieties and in the parental variety.

Krug yellow dent, an open-pollinated variety, was used as foundation material in developing three synthetic varieties by two cycles of recurrent selection. Selection was directed toward high combining ability in two of the synthetics and toward low combining ability in the third. The two second-cycle high-combining synthetics were derived from the same first-cycle synthetic and differed only in that more lines were used in the production of one than in the other.

Seventy-six S_0 plants in each of the four populations were outcrossed to WF9 x M14

[1]Doctoral thesis no. 1520, submitted March 25, 1954. Chairman of Committee, G. F. Sprague, Department of Agronomy.
[2]B.Sc., University of Nebraska, Lincoln, Nebr., 1941. M.Sc., Ibid., 1949.

and the test crosses grown in a yield trial. The test crosses from the high-combining synthetics were, on the average, significantly higher in yield, 5.1 and 5.5 bushels per acre, than those from Krug. Likewise, the test crosses from the low-combining synthetic averaged significantly lower in yield than those from Krug. The difference in this case was 2.3 bushels per acre. It was concluded that the two cycles of recurrent selection had been effective in modifying combining ability and that the high-combining synthetics would be better sources of new lines than would Krug.

Self-pollination was continued in the eight S_1 lines intercrossed to produce the first-cycle high-combining synthetic and the seven lines intercrossed to produce the first-cycle low-combining synthetic. The lines were advanced to the S_4 or S_5 generation, selection at each generation being based on test-cross yields. The average test-cross yield of 22 lines selected for high combining ability did not differ significantly from the average yields of test crosses from the high-combining synthetics. Similarly, the test crosses of eight lines selected for low combining ability gave yields essentially equal to the average yield of test crosses from the low-combining synthetic.

The testing program in the continuous-selfing series had included testing in two years, testing at two locations, and in some cases a combination of both. In contrast, selection in the recurrent selection series was based on tests each grown at a single location and for a single year. Considering the difference in intensity of testing in the two series, recurrent selection would be considered equal and perhaps superior in efficiency to the continuous selfing procedure. It was pointed out that only small additional advances could be expected in the selfing series since genetic variability within S_5 lines would be quite low. On the other hand, enough variability for additional gains was still present in the recurrent selection populations.

Relative levels of genetic variability for combining ability in the three second-cycle synthetics and Krug were estimated through the variance component analysis method. The synthetics were significantly less variable than was Krug. The differences in variability were greater than had been anticipated. A part of the reduction in variability was attributed to shifts in gene frequency resulting from selection. It is not likely, however, that changes in gene frequency accounted for more than a small fraction of the reduction. A large portion of the reduction in variability was considered a result of inbreeding. This required the assumption that the actual rate of inbreeding was considerably above the minimum expected. The increased rate of inbreeding was explained as possibly resulting from non-randomness of mating among the selected S_1 lines, differences in yielding ability of S_1 lines *per se*, differences in prepotency among S_1 lines, and differences in viability of the S_1 lines intercrossed by natural pollination in an isolated plot in the first cycle of recurrent selection.

The importance of maintaining genetic variability at a high level was discussed. Methods of minimizing inbreeding in a recurrent selection program were reviewed and discussed.

POPULATION SPECIFICATIONS OF THE EUROPEAN CORN BORER, PYRAUSTA NUBILALIS (HBN.), IN FIELD CORN[1]

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The economic entomologist has come to realize that statistical procedures are powerful research tools. As a result, the use of statistically designed experiments by entomologists has increased considerably in the past two decades. The use of several common tests of significance, however, assumes normality or a certain approach to normality in the data being analyzed. From work done by entomologists and statisticians interested in entomological problems it has been learned that, in general, insect data have a tendency to be non-normal and more variable than expected. This has been found to be true of data from European corn borer populations which are expected to follow a Poisson distribution but are generally poorly fitted by it.

[1]Doctoral thesis no. 1514, submitted March 12, 1954. Chairman of Committee, Tom A. Brindley, Department of Zoology and Entomology.

[2]B.S., Iowa State College, Ames, Iowa, 1941. M.S., Ibid., 1947.

In order better to understand the nature of the population distributions, the following areas were investigated: (1) the mathematical function which best graduates the data, (2) the appropriate transformation to use on the data in order to stabilize the variance, (3) the efficiency of size and shape of plot, and (4) the size of sample per plot which should be used if plot means are to be analyzed.

The data consist of the number of borers, by instar, dissected from 7093 corn plants. Four, one-third acre experimental areas, selected from four different corn fields during the summers of 1952 and 1953, were studied. All plants in the 1952 experimental area were dissected while all three experimental areas in 1953 were sampled at the rate of one plant from each hill. The plant dissected was selected at random from those present in each hill. The information from each plant dissected was punched on an IBM card and all tables for the analyses made from the individual cards.

Four contagious distributions found in the literature are reviewed and a new contagious distribution based on the binomial law is presented. A full mathematical discussion of all five contagious distributions is presented in the appendix. The name Poisson binomial contagious distribution was given to the new distribution since it consists of a binomial parameter distributed over a field as a Poisson variate. Three of the five distributions discussed were chosen to fit to the observed frequency distributions, these were: the negative binomial, Neyman tye A, and the Poisson binomial. The fitting of all three distributions is discussed in detail.

It was found that the Poisson binomial gave, in general, the best fit when all the corn stalks in an entire field were dissected or the population mean was less than one. When the field was sampled and the population mean was greater than one, the negative binomial gave the best fit. Tables showing the observed and theoretical frequencies for nine frequency distributions are given, together with charts showing the observed and the best fitting theoretical frequencies.

The use of transformations is discussed with particular reference to the Beall inverse hyperbolic sine transformation and a new square root transformation analogous to the square root transformation for data following the Poisson law. Both transformations were investigated as to their effect in stabilizing the variance and as to the resulting normality on the transformed scale. It was found that the square root transformation was more successful in stabilizing the variance over the range of population means studied, 2.03 to 0.16, than the inverse hyperbolic sine transformation. On the other hand, the inverse hyperbolic sine transformation was more successful than the square root transformation in imparting normality to frequency distributions with low means, less than one.

Using the data from the experimental area which had been completely dissected it was found that the variances per unit plot followed the H. Fairfield Smith law for heterogeneity. A weighted multiple regression equation was fitted to the observed variances per unit plot using the ratio of the width of plot to the length of plot as a shape factor. The regression coefficient for the shape factor, however, was not significantly different from zero and that variable was discarded. It was found that there was not a sufficient increase in efficiency in using a 324-hill plot over a 216-hill plot to make the use of the larger plot worthwhile. It was determined that the best shape of plot for insecticide experiments is a plot four or six rows wide by 126 feet long.

For plot work in which the plot totals are to be used in the analysis it was found that the minimum sample size should be twenty plants selected at random from each plot. A method for estimating sample size is proposed, using the beta coefficients for the three distributions studied and a special log log chart which is provided.

NUTRITIONAL ACTION OF AUREOMYCIN AS RELATED TO AN UNIDENTIFIED GROWTH FACTOR[1]

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Department of Animal Husbandry

The present study, conducted in eight separate experiments, was initiated in an attempt to demonstrate increased intestinal synthesis of an unidentified growth factor for swine as a result of the feeding of aureomycin.

Five of the trials were conducted using a total of 120 head of swine individually fed in wire bottomed cages equipped with self-feeders and automatic waterers. One trial involved 36 head of cross-bred swine group fed in pens with concrete floors. Two trials were run using weanling rats.

Bacteriological techniques were used to isolate fungi from the feces of growing-fattening swine fed 5 mg. of aureomycin hydrochloride per pound of ration. Forty different strains of fungi were isolated and mass cultures of the different species were tested for acute toxicity for mice. The cultures were increased in the biochemical laboratories on the Iowa State College campus. Selected nontoxic cultures (ranked according to the frequency with which the organism appeared in the feces) were fed to growing-fattening swine maintained both on wire and concrete floors.

When placed upon experiment, both the pigs and rats were fed a corn-soybean oil meal type basal ration fortified with minerals, including trace minerals, as well as all known crystalline vitamins which were commercially available.

Strains of the following species of organisms were added, either singly or in combination, to the basal ration; Aspergillus niger, A. chevalieri, A. flavus, Oospora sp., Botrytis sp., Circinella sp., and a Mucor sp.

Varied levels of the cultures (5 to 20 per cent) were added to the basal ration as fermentation broth and also in a concentrated form.

A randomized block statistical design was used in all trials of this study.

The results of four pilot experiments using swine indicated that cultures of A. flavus strain 18 contained an unidentified growth factor. The addition of A. flavus 18 (as fermentation broth) in amounts equal to 10 per cent of the total dry weight of the ration caused a 0.16 pound increase in the average daily gains over that obtained using the basal ration. The inclusion of cultures of A. niger and A. chevalieri had a depressing effect on average daily gains.

The fifth trial, using individually fed swine, as well as the trial using swine (group fed) in pens with concrete floors, involved feeding concentrated fractions of a culture of A. flavus 18 which had been increased, divided into its fractions, and then the filtrate concentrated 27 times and the mycelium concentrated 580 times. An analysis of the data obtained as a result of feeding cultures of fungi to growing-fattening swine in wire bottomed cages did not indicate any statistically significant positive effects due to the ration treatments.

Fractions of A. flavus 18 (either filtrate or mycelium or a combination of the two fractions) included in the ration in amounts equivalent to the amount present in 10 per cent of the original fermentation broth increased daily gains over those of the basal ration when fed to weanling pigs (group fed) in pens with concrete floors. The filtrate fraction increased daily gains 0.40 pound over those of the basal ration (1.33 pounds as compared to 0.93 pound) and caused a saving of 22 pounds of feed required to produce 100 pounds of gain.

The magnitude of the increased gains produced by the mycelium fraction and a combination of the two fractions was less than that of the filtrate fraction (1.10 and 1.24 pounds, respectively).

[1]Doctoral thesis no. 1526, submitted May 6, 1954. Chairman of Committee, Damon Catron, Department of Animal Husbandry.

[2]B.A., University of Iowa, Iowa City, 1942. B.S., Iowa State College, Ames, Iowa, 1947. M.S., Ibid., 1950. Research Fellow, Agricultural Experiment Station.

RELATIONS BETWEEN PARTS OF LACTATIONS AND THE REAL PRODUCING ABILITY OF HOLSTEIN COWS[1]

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The repeatabilities, heritabilities, and genetic correlations for milk and butterfat production for varying portions of lactation were studied on 599 records by 253 different cows in the Iowa State College Holstein herd. These were all the completed lactations of at least 243 days duration during the period from 1940 to 1952.

Weights of milk were recorded for all milkings and the milk was tested one day each month. The fat production was computed as the product of the monthly fat test and the actual milk produced during the month.

Repeatability values were computed for both milk and fat production for monthly and cumulative periods of the lactation. Components of variance for cow (C) and error (E) were used to obtain repeatability values, which are the correlations between records made by the same cow in different lactations. About 40 per cent of the 253 cows had only one record. Insofar as single-record cows were not allowed to produce a second time because of low production in the first lactation, this would have made the estimates of both E and C somewhat lower than they would have been in an unselected population. It appears that both would have been biased in about the same proportion and, therefore, that the repeatability estimate, $\frac{C}{C+E}$, would be biased little or not at all, although this point may merit more detailed study.

Individual monthly repeatability values ranged from 0.26 for ninth month to 0.59 for second month of milk production and from 0.15 for ninth month to 0.52 for first month of fat production. Repeatability values for cumulative lengths ranged from 0.51 for the first 305 days to 0.61 for the first 90 days of milk production and from 0.43 for the first 305 days to 0.57 for the first 90 days of fat production. The repeatability values indicate that the later single months are more strongly affected by environmental variations than are the early months.

The standard age correction factors developed for 305 day total lactations are definitely inaccurate for monthly parts of lactations. This is mainly due to the higher persistency of first lactations. Using the standard 305 day age correction factors on monthly segments of the first lactation definitely undercorrects the early months and overcorrects the later months. When the standard 305 day factors were applied to increasingly longer cumulative periods, their adequacy increases as the period approaches the 305 day period.

Heritability values were computed by doubling the intra-sire regression of daughter on dam. The daughter-dam pairs used in this part of the study numbered 157. First records only were used to calculate all ten of the cumulative heritabilities, but average records were also used to compute heritability of single 30 (or 31) day periods and eight, nine, and ten month cumulative periods. When corrected to a single record basis, the heritability values found for single months ranged as low as -0.08 for the tenth month to as high as 0.40 for the sixth month of milk production and from -0.15 for the tenth month to 0.32 for the second month of fat production. The standard errors for these estimates were of the order of 0.18 to 0.22 and could have made the high and low values so extreme. Heritabilities for cumulative periods ranged from 0.34 for the first 120 days to 0.63 for the first 274 days of milk production and from 0.30 for the first 120 days to 0.47 for the first 243 days of fat production. Heritabilities of the magnitude found for the cumulative periods indicate that phenotypic selection should cause noticeable genetic improvement in milk and fat production.

Genetic correlations between cumulative parts and whole (eight, nine, and ten months) lactation production were computed using only the first records. Values approaching and exceeding unity were found for many of these genetic correlations. Whether the excess over unity was caused only by sampling errors or also by selection or some other feature of the data is not clear. Such large genetic correlations indicate that genes which influence production during the early part of the lactation are the same

[1]Doctoral thesis no. 1538, submitted June 1, 1954. Chairman of Committee, Jay L. Lush, Department of Animal Husbandry.

[2]B.S., Inter-American Instutute of Agricultural Sciences, Turrialba, Costa Rica, 1946. M.S., Ibid., 1948. Graduate Assistant, Agricultural Experiment Station.

genes which influence production during the other parts of the lactation, and that the actual differences in persistency are only slightly if at all genetic. Automaticity between a part and the whole is not the reason for the high correlations obtained here since the genetic correlations were ratios whose numerators were obtained by correlating trait i in the dam with trait j in the daughter and vice versa, while the denominators were obtained by correlating trait i in daughter and dam and trait j in daughter and dam. For example, the genetic correlation between cumulative 60 day and cumulative 305 day production is obtained by correlating 60 day production in the dam with 60 day production and 305 day production in the daughter and by correlating 305 day production in the dam with 60 day and 305 day production in the daughter. If the genetic relations are really as high as the estimates found here, selection for part record would cause almost or fully as much genetic gain in whole lactation production as would selection on whole records.

SELECTION TECHNIQUES IN COTTON BREEDING[1]

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Two general methods for improving cotton yield and quality have been in use for many years. They are (1) pure line selection within variable commercial varieties and (2) hybridization followed by subsequent selection. These methods have been successful in producing varieties now widely used in the cotton belt. Considerable time is spent both in the field and the laboratory to evaluate selections for fiber qualities, lint per cent, plant maturity and general agronomic desirability. It would be of value to know how much emphasis should be placed upon character measurements in single plants. It also becomes important to know which hybrids offer the best opportunity for obtaining outstanding lines and at what stage in the breeding program this could be determined. In this study, the agronomic performance of several American Upland cotton crosses were studied through the F_5 generation in an attempt to find at least partial answers to such problems.

The data obtained in this study showed that F_1 crosses between commercially acceptable varieties may yield considerably more than the higher yielding parent, but possibly to no greater extent than varieties of other largely self-pollinated crops like soybeans, wheat or flax. Cross-pollination may be sufficiently high in some varieties and under some conditions to consider the feasibility of commercial production of F_1 seed. Obviously, this practice could not become successful unless a male sterility mechanism could be incorporated into breeding stocks.

Yield of the F_1 or bulk F_2 generations did not consistently predict the yield potential of a hybrid in subsequent generations. Some hybrids ranked relatively high in the F_1 or F_2 but were low in the F_5. For this reason it becomes necessary to study each individual hybrid. The data show that hybrids with Deltapine as one parent ranked fairly high in the F_1 and continued to do so in later generations.

Evaluations for lint per cent, lint index, seed size, and boll size in the F_1 or bulk F_2 populations were indicative of the level of performance expected in subsequent generations. For these characters entire crosses could be eliminated on the basis of performance in either the F_1 or F_2 generations. It was found that parental varieties which ranked high for these characters tend to produce hybrids which also ranked high. As is true for other crops, it appeared that the cotton breeder often can determine which varieties to use in hybrids by evaluating the parents for desired characters.

To test the value of selection on a single plant basis, F_2 plants were chosen as phenotypically high and low and at random for yield. These selections were tested in unreplicated F_3 progeny rows and in replicated field trials in the F_4 and F_5 generations. It was concluded that as a general practice selection for yield on a single plant basis was unjustified in cotton. For all crosses, except one, it appeared that it would be as

[1]Doctoral thesis no. 1511, submitted March 11, 1954. Chairman of Committee, I. J. Johnson, Department of Agronomy.

[2]B.S., Illinois Wesleyan University, Bloomington, Ill., 1940. M.S., Agricultural and Mechanical College of Texas, College Station, Texas, 1942.

profitable to select a random sample of the F_2 population as selecting phenotypically superior plants.

The qualities upon which the cotton fiber price is based are grade and length of lint with some attention paid to fineness and strength of fiber. In addition, the grower strongly emphasizes yield and lint per cent. It follows that it is important to know the extent and kind of relationships among and the heritability of these characters. The phenotypic correlations obtained in the F_2, F_3, and F_4 generations showed that high lint per cent was correlated with high yield, high lint index, small seed, and to some extent with long and weak fiber. Large boll was correlated with high lint index, large seed, coarse fiber, and to a lesser degree with long and strong fiber. Strong fiber was correlated with small seed, low production, and possibly low lint per cent. These correlations suggested that it should be possible to obtain a high producing line with high lint per cent but weak fiber and small seed. Such a line most likely would have a small boll since small seed and small boll were closely correlated.

The phenotypic association between any two characters may be due ot the combined effects of the genotype and environment. Genetic correlations were used in an attempt to separate the two causes and were calculated by the use of reciprocal parent-progeny regressions. The genetic correlations involving lint per cent, lint index, seed size, and yield were not greatly different from the corresponding intergeneration phenotypic correlations. Those involving yield were inconsistent.

The possibilities of progress by selection is largely determined by the heritability manifested by a character. In this study heritability estimates were determined by calculating the regression of progeny means in F_3 on F_2 single plants, progeny means in F_4 on F_2 single plants and F_4 means on F_3 means. The regressions of F_4 means on F_3 means gave the highest values. Heritability of lint per cent ranged from 62 to 76 per cent, suggesting that selection for lint per cent would be effective on an individual plant basis. Heritability of yield was too erratic to justify selection of single plants and supports the common practice among cotton breeders of eliminating undesirable agronomic types before evaluating for yield.

INFRARED SPECTRA OF SOME AROMATIC COMPOUNDS[1]

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A study has been made of the effect of substituent groups on the infrared spectra of substituted benzenes, with particular emphasis on the region from 11.5 to 14.5 microns, where the absorption bands correspond to the out-of-plane vibrations of the hydrogen atoms on the ring. To a first approximation, the frequency of the absorption bands is determined only by the number and arrangement of substituents, but some substituents, particularly nitro and carboxyl groups, cause radical changes in the spectra.

In para-disubstituted and 1,2,4-trisubstituted benzenes having a nitro or carboxyl group as one of the substituents, an absorption band was found near 13 microns that is not normally present in aromatic compounds with this symmetry of substitution or in other aromatic nitro compounds or carboxylic acids. This absorption band must be due to some vibration of the aromatic nucleus, but the nature of the vibration is unknown.

A more general effect of nitro and carboxyl groups is a shift of the out-of-plane hydrogen bending vibrations to higher frequency. The possibility that the shifts could be caused by the effect of the mass of the group is considered, and it is shown that for most groups there is a relation between the mass of the atom attached to the ring and the frequency of the absorption band, but that nitro and carboxyl groups act as though they were much lighter than the mass of the nitrogen or carbon atom. The possibility that the shifts are caused by a resonance effect is ruled out by the fact that the nitrile group has only the effect to be expected when the atom attached to the ring is a carbon atom.

[1]Doctoral thesis no. 1479, submitted December 9, 1953. Chairman of Committee, V. A. Fassel, Department of Chemistry.

[2]B.S., Brooklyn Polytechnical Institute, Brooklyn, New York, 1951.
Research Associate, Institute for Atomic Research.

It is possible to explain these band shifts on the basis of a hydrogen bond between the oxygen atoms of the nitro or carboxyl group andaa hydrogen atom on the ring ortho to the group. Data from X-ray crystal structures of para-dinitrobenzene and diethyl-terephthalate indicate that the distance between the oxygen atoms and the ring hydrogen atoms is short enough for the formation of a hydrogen bond. By means of this hydrogen bond it is also possible to explain the effect of steric interactions on the frequency of the out-of-plane hydrogen bending vibration in ortho-disubstituted benzenes as well as certain changes in the spectra of geometric isomers with the same symmetry of substitution, such as 2,4-dimethylbenzoic acid and 2,5-dimethylbenzoic acid.

The C-H stretching vibrations near 3000 cm^{-1} show no pronounced effect of the nitro or carboxyl group. It is shown that this observation does not necessarily disprove the hydrogen bond hypothesis.

The in-plane bending vibrations of aromatic compounds give rise to absorption bands between 8.5 and 10.5 microns. In the monosubstituted benzenes the frequency and intensity of the absorption bands is determined by the atom attached to the phenyl group, with negligible influence from the rest of the molecule. The band patterns are constant enough so that it is possible to recognize the presence of groups such as phenyl-silicon by observing the spectrum in this region. Nitro and carboxyl groups do not have an unusual effect on the spectra of this region.

The spectra of phenyl acetate and benzyl chloride were studied in the liquid and solid states. The changes that occur in the spectrum of benzyl chloride on going from the liquid state to the solid state indicate that there are at least two rotational isomers present in the liquid state. In phenyl acetate no such changes occur, indicating that rotational isomerism does not occur in this molecule. This is in accord with an interpretation of the small dipole moment of phenyl acetate.

Some data on the spectra of substituted benzenes in the 15 to 25 micron region are presented. For the monosubstituted benzenes it is possible to correlate the absorption frequency with the mass of the element attached to the benzene ring. There is a consistent shift of the absorption bands in this region to lower frequency as the mass of the substituent atom increases. Similar correlations appear to be possible for the para-disubstituted benzenes, though in the ortho-disubstituted benzenes steric factors make any simple spectra-structure correlations impossible.

A method is presented of measuring the relative concentrations of phenyl and para-tolyl groups in arylsilanes by means of the absorption bands between 11.5 and 14.5 microns. The method is unusual in that the sum of two band intensities must be used to determine the concentration of phenyl groups instead of measuring just one absorption peak. The analytical curve is a straight line passing through the origin, and the precision of the analysis is apparently limited only by the precision of the photometric measurements.

THE THEORY OF PSYCHROMETRY[1]

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Department of Chemical Engineering

The analogy between fluid friction, heat transfer and mass transfer is used in this paper to describe the behavior of the wet- and dry-bulb psychrometer. Equations are derived to describe the velocity, temperature, and concentration profiles for the flow of fluids through the round pipes based on a new correlation of the Prandtl mixing length with pipe diameter for fully turbulent flow. These equations are extended to apply to the case of flow of a fluid at right angles to a single cylinder.

[1]Doctoral thesis no. 1449, submitted July 17, 1953. Chairman of Committee, B.F. Ruth, Department of Chemical Engineering.

[2]B.S., Northwestern Technical Institute, Evanston, Ill., 1943. M.S.E., University of Michigan, Lansing, Mich., 1948. Instructor.

The resulting psychrometric equation is

$$\frac{(p_w - p_a)\lambda_b}{P(1 + h_r'/h_c)(t_a - t_{wb})} = \frac{M_m}{M_a} c \frac{(1.072\, S^{2/3} - 1) + 0.38\, Re^{0.15}}{(Pr^{2/3} - 1) + 0.38\, Re^{0.15}}$$

where

p_w = vapor pressure of the vaporizing liquid at the wet-bulb temperature
p_a = partial pressure of the active component actually present in the gas stream
P = total pressure of the system
λ_b = latent heat of vaporization of the active component at the wet-bulb temperature plus the sensible heat required to heat the vapor from the wet-bulb temperature to the temperature at the boundary of the fusion layer
t_a and t_{wb} = true gas temperature and wet-bulb temperature, respectively
h_r' = modified radiation heat transfer coefficient:

$$h_r \frac{t_w - t_{wb}}{t_a - t_{wb}}$$

h_r = radiation coefficient found from modified form of the Stefan-Boltzmann equation:

$$h_r = 0.00692 \epsilon_w \left(\frac{T_{av}}{100}\right)^3 \left[1 + 0.25 \left(\frac{\Delta T}{T_{av}}\right)^2\right]$$

t_w = temperature of enclosure surrounding the thermometers
T_{av} = arithmetic mean of t_w and t_{wb} expressed in °R
ΔT = temperature difference, $(t_w - t_{wb})$, in °R
ϵ_w = emissivity of the termometer taken here as 0.90 for the wick
h_c = convection heat transfer coefficient found by:

$$h_c = \frac{k}{D} 0.45\, (10\, Re)^{0.235}[1 + 0.1595 \log (10\, Re)]$$

k = thermal conductivity of gas
D = diameter of thermometer
Re = Reynolds number = $Du\rho/\mu$
u = linear velocity of gas flow
ρ = density of gas
μ = viscosity of gas
M_m = molecular weight of gas plus vapor it contains
M_a = molecular weight of active component (vapor)
c = heat capacity of gas
S = Schmidt number = $\mu/\rho D_v$
D_v = diffusivity of vapor through gas
Pr = Prandtl number = $c\mu/k$.

To determine the true gas temperature, t_a, where the dry-bulb thermometer is subject to radiation error, it is necessary to use a heat balance expressed by

$$h_r(t_w - t_t) = h_c(t_t - t_a)$$

where

t_t = temperature indicated by thermometer and all other symbols are as defined above.

The emissivity, ϵ, to be used in the h_r term in this case would be that of a plain mercury-glass thermometer which is shown to be 0.73.

Equations are also given here to predict friction factors for the flow of a gas at right angles to a single cylinder.

All of the equations given apply whether the system used is the common air-water vapor system or any other combination of gas and vapor, providing the physical properties such as go to make up the Schmidt and Prandtl groups are known. Conversely, if the properties are not known, this provides one way of determining them experimentally.

ACTIVITIES OF ALIPHATIC ACIDS AND ALCOHOLS IN BINARY AQUEOUS SOLUTIONS[1]

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A rapid and accurate new method for the determination of activities of both components in binary mixtures of volatile solvents is described. The method involves the transfer of an equilibrium mixture of vapors from above the solution of interest to a previously evacuated reservoir flask. The pressure is read after total pressure equilibrium is established above the solution. The equilibrium mixture of vapors is condensed in a liquid nitrogen trap and later analyzed interferometrically.

The crucial feature of the apparatus was a solenoid operated intermittent bleeder valve which insured the transfer of an equilibrium mixture of vapors from the generator flask to the reservoir flask. Other valves which permitted a continuous flow of vapors were not satisfactory, as results were always characterized by high partial pressures for the faster evaporating component. Complete directions are given for the construction of the intermittent bleeder valve.

Activity coefficients of both components at 25.00 + 0.02°C in water-methanol, water-ethanol, water-propanol-1, water-acetic acid, water-propionic acid, and water-n-butyric acid systems determined by this method are given and compared with best literature values.

The activity coefficient data as determined were made self-consistent as required by the Duhem-Margules equation. The data were found not to fit the Margules equation, i.e., plots of the $\log \gamma_A/X_W^2$ and $\log \gamma_W/X_A^2$ against the mole fraction organic component X_A did not give straight lines of zero slope. (Subscript A refers to alcohol or acid and subscript w to water.) Instead, plots of this type led to straight lines with a nonzero slope or to parabolic shaped curves. Therefore, these curves were fitted with linear or quadratic equations over the entire range of concentration or over parts of the range in cases where it was difficult to fit the curve with one set of constants. The data are represented by,

$$\frac{\log \gamma_A}{X_W^2} = a + bX_A + cX_A^2 \quad ,$$

the Duhem-Margules equation requiring,

$$\frac{\log \gamma_W}{X_A^2} \qquad a - \frac{b}{2} \qquad + \qquad b - \frac{2c}{3} \qquad X_A + cX_A^2 \quad .$$

The constants a, b, and c are given for the system determined. In general, the data are consistent with the Duhem-Margules equation.

Specific interactions at infinite dilution (specific free energy effects) are discussed. Specific free energy effects for completely miscible systems are calculated from experimental activity data; those for incompletely miscible systems are estimated from solubility data. Explanations of specific free energy effect variations in terms of component structures, functional groups, and lengths of aliphatic chains are advanced.

The concentration dependence of activity coefficients is discussed. The excess free energy of mixing, i.e., the free energy in excess of the ideal free energy of mixing, is calculated for all the systems determined. This excess free energy of mixing is discussed in terms of enthalpy and excess entropy of mixing.

A complete discussion is given of the errors inherent in the method for determination of the activities. Several modifications are suggested for improving the apparatus and for applying it to other nonaqueous components.

[1]Doctoral thesis no. 1454, submitted August 7, 1953. Chairman of Committee, R. S. Hansen, Department of Chemistry.

[2]B.A., Luther College, Decorah, Iowa, 1949. Research Assistant, Institute for Atomic Research.

ENGINEERING REPLACEMENT ECONOMY IN IOWA INDUSTRY[1]

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Department of General Engineering

Engineering Economy is the title applied to a body of methods used to make the wisest and usually most economic choice among several possible alternatives of such technical complexity that engineering knowledge is essential. The most usual and difficult engineering economy study presents itself when one of the alternatives is the status quo, i.e., the presently existing machine or structure still capable of rendering service if retained. It is in this broad area of replacement studies that much erroneous thinking has occurred. Very little evidence of factual information in this area has been found. None was found that was directly applicable to Iowa.

The investigator desired to secure data about actual replacement economy practices of manufacturing plants in the state of Iowa. Fully to describe the replacement economy practices, it was also necessary to secure data on other closely related practices including depreciation, accounting, and appraisal. The stated objectives of the investigation were to secure data on the previously mentioned practices, to compare this data where possible with currently known data, to interpret this data by comparison with conventional or suggested practices, and to report the results of the investigation back to the Iowa manufacturing plants for their use. The study was intended to be primarily descriptive in nature rather than interpretive.

Manufacturing plants in Iowa number over 2,100. From this total 300 were selected according to best statistical techniques. A questionnaire composed of 26 questions was sent by mail to the selected group requesting their response.

The most valuable findings of the investigation are enumerated below. Certain of the attributes reported were related to the size of the plant as measured by the number of employees. The relationships were tested by the proper statistical techniques and are noted where they exist. Exact percentages have been rounded to the closest simple fraction. The findings were as follows:

1. Response to the questionnaire was related to the size of the plant. As the size of the plant increased, the proportion of responses to number samples increased.
2. Evidence was found to indicate that the nonrespondent portion of the sample would give essentially the same answers as the respondent portion of the sample. Therefore, the uncertainty due to some questionnaires not being returned was reduced.
3. The organization of Iowa plants into corporations, partnerships, or sole proprietorships was essentially in the same proportion as the United States taken as a whole.
4. Where a plant was a branch of a larger multi-plant company, only one-eighth of such plants were allowed any local voice in policies regarding engineering economy.
5. The average number of employees in an Iowa manufacturing plant was 91. The estimate of the total number of employees engaged in manufacturing in Iowa was 195,500.
6. The distribution of the number of plants in each of the six size groups was essentially the same as that of the United States taken as a whole.
7. Appraisals, when made, were predominantly for the purpose of insurance valuation. More large plants had made appraisals than small plants.
8. The average appraisal gave a valuation that varied 20 per cent from total assets as shown on the balance sheet for a particular plant.
9. Nearly half the plants calculated depreciation for only one reason, namely, income tax deductions. However, larger plants listed several other reasons for determining depreciation.
10. Slightly over half the plants used life values from Bulletin F, U.S. Treasury Department, solely. This practice was related to the size of the plant. Larger plants used Bulletin F to a lesser extent than smaller plants.
11. Over four-fifths of the plants used straight depreciation exclusively.
12. An increase in the use of declining balance depreciation, particularly by smaller plants, was found by comparison with data reported 15 years ago.

[1]Doctoral thesis no. 1548, submitted June 3, 1954. Chairman of Committee, James P. McKean, Department of General Engineering.

[2]B.S., Iowa State College, Ames, Iowa, 1943. M.S., Ibid., 1949. Instructor.

13. Nearly one-half the plants stated that the values of useful life given in Bulletin F, U.S. Treasury Department, were satisfactory or too short. This finding was contrary to much published opinion. As the size of the plant increased, the satisfaction with the values of useful life in Bulletin F decreased.
14. Almost three-fourths of the plants favored a proposed ruling by the U.S. Treasury Department that would allow plants to calculate depreciation for income tax purposes with a useful life of their own choosing and shorter than those given in Bulletin F.
15. Almost one-third of the plants would not consider replacement of equipment that was not worn out. As the size of plant increased, the willingness to consider replacement increased.
16. The average pay-off period among those who use it as a criterion for signaling replacement was 3.0 years. This average for Iowa did not differ from two reported U.S. averages of 2.7 years and 3.3 years. Over four-fifths of the plants stated they had no policy on the length of the pay-off period.
17. Securing capital to finance economic replacement was a more important problem to one-eighth of the plants than showing the economy of the replacement. As the size of the plant increased, the problem of securing capital decreased in importance.
18. Plants in Iowa attempted to estimate conditions affecting an engineering economy study three to four years into the future. As the size of plant increased, estimates of conditions were attempted farther into the future.
19. Formulas for determining replacement decisions were used by less than one twenty-fifth of the plants.
20. A hypothetical problem yielded information equivalent to several direct questions. The problem technique with further development should be a useful device in studies of this nature. Some findings from the problem were as follows:
 a. Actual calculations were observed to be widely variable.
 b. Rates against an arbitrary scale of good practice, the quality of problem solutions was not related to size of plant.
 c. For the specific data of the problem almost three-fourths of the respondents chose to replace the present machine with the proposed machine. The problem data were chosen so that a replacement was definitely indicated.
 d. Some evidence was found that the largest sized plants were more conservative about replacement decisions than all other sized plants.
 e. Sunk costs were improperly handled or not considered at all by every respondent who showed calculations except one.

These findings are presented with the author's belief that useful information about engineering replacement economy practice has been made available, particularly for the state of Iowa.

TAXONOMY AND DISTRIBUTION OF THE GENUS SPARTINA[1]

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This investigation deals principally with the redetermination of the limits of and the variability within the species of Spartina, a genus of grasses. Results of the study show the genus to be composed of sixteen species and two minor forms. Only one minor nomenclatorial change is proposed. Because the genus had not, heretofore, been properly typified, Spartina cynosuroides (L.) Roth is selected as the type species.

The sixteen species are placed in three complexes on the basis of morphological similarity. Species of the first complex possess hard, slender culms and spikelike panicles composed of numerous, short, closely imbricate, twisted spikes. Rhizomes are usually wanting; if present, they are short and knotty. S. arundinacea of several

[1]Doctoral thesis no. 1452, submitted July 29, 1953. Chairman of Committee, Richard Pohl, Department of Botany and Plant Pathology.

[2]B.S., Baldwin-Wallace College, Berea, Ohio, 1948. M.S., University of Michigan, Lansing, Mich., 1950. Instructor, Industrial Science Research Institute.

South Atlantic and Indian Ocean islands, S. ciliata of southern South America and S. spartinae of North and South America are members of the first complex.

The second complex consists of species with soft, fleshy, succulent culms; pilose pubescence on parts of the spikelets; and soft, flaccid rhizomes with inflated scales. The plants are usually limited to the inter-tidal zone of coastal marshes. Species admitted to this complex are S. alterniflora of North and South America and Europe, S. foliosa of the Pacific coast of North America, S. longispica of the region near the mouth of the River Plate in South America, S. maritima of Europe and Africa, S. neyrautii of southwestern France and S. townsendii of England and France.

Plants of the third complex are characterized by hard culms; nonspikelike panicles; usually spreading nontwisted spikes; and hispid pubescence on the spikelets. Most of the species possess firm rhizomes; the scales are not inflated. Species of the third complex are S. bakeri of salt and fresh water habitats in Florida and Georgia, S. X caespitosa of disturbed ground in and around coastal marshes from Maine to Maryland, S. cynosuroides of coastal marshes of eastern United States, S. densiflora of South America, S. gracilis of the western plains and mountains of North America, S. patens of the salt marshes in eastern United States and S. pectinata of transcontinental distribution in northern North America.

Within several of the species (S. alterniflora, S. cynosuroides, S. patens, S. pectinata and S. spartinae) at least two levels of polyploidy have been found. In none of these species have suitable means been found for identifying the various levels of polyploidy except by chromosome numbers.

Hypotheses of hybrid origin for two species were investigated. Data based upon the analysis of morphological structures are introduced into a numerical index of hybridization. Results of this analysis lend considerable support to the theory that S. longispica has originated by means of hybridization between S. alterniflora and S. densiflora. This hybrid is presumed to be of monophyletic origin. S. X caespitosa is thought to have originated by repeated crosses involving S. patens and S. pectinata. The plants of this polyphyletic hybrid swarm have been shown to reproduce vegetatively. There is no evidence that the hybrids produce viable seed. The plants of this hybrid swarm are found only on disturbed ground. This fact may lend further support to the hypothesis of hybrid origin.

FISH POPULATIONS IN SOME IOWA FARM PONDS IN RELATION TO PAST HISTORY AND MANAGEMENT[1]

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Department of Zoology and Entomology

Iowa's 3,900 farm fish ponds are largely located in the southern part of the state where other fishing waters are relatively scarce. This study was conducted to ascertain the present condition of farm fish ponds and to search for factors in their history primarily contributing to success or lack thereof of their fish populations.

All ponds within a delimited area of approximately 296 square miles in the western half of Marion County, Iowa, and known to have been stocked with bass and bluegills, were included in the study. Most of the ponds were on silt loam soils and some may have been in contact with clay sub-soils.

The ponds received a preliminary inspection and, if the pond and its fish population justified it, a detailed study of the fish population. Fish were gathered by seining, trapping, and rotenone treatment, and data on length and weight of individual fish were collected. Populations of each species were estimated, where possible, by the marking and recovery technique.

The ponds varied in size from one-tenth acre to two acres. There was little discernible relationship between pond size and success of fish populations other than that ponds smaller than one-half acre were less successful than were ponds one-half acre and larger, and ponds of one-tenth acre were not successful.

[1]Doctoral thesis no. 1430, submitted July 3, 1953. Chairman of Committee, Kenneth D. Carlander, Department of Zoology and Entomology.

[2]B.S., Iowa State College, Ames, Iowa, 1939. M.S., Ibid., 1942. Associate, Agricultural Extension Service.

The stocking combination of largemouth black bass and bluegills produced fishing in new ponds within two years under favorable conditions. This combination was used in 26 ponds, and 58 per cent of them were successful. A combination of bass-bluegills-bullheads was used in 18 ponds and 22 per cent of these were successful.

The ratio of bluegills to bass as actually stocked varied from a low of 4 to 1 to a high of 25 to 1, and the rates of stocking expressed as numbers of bluegills varied from 200 to 2500 per acre in combination with bass. There was no relationship apparent between stocking ratios, rates per acre, or pond age with success of the fish population.

Of the practices generally recommended for the management of farm fish ponds the only one widely followed by farmers was that of fencing to exclude livestock from the immediate pond area. Fertilization as a management practice was not widely accepted by pond owners. Fishing pressure at most of the ponds was very light. Annual harvest at the six most heavily fished ponds was estimated to be not more than 65 pounds per acre; harvest at twelve others was estimated at not more than 20 pounds.

Turbidity due to fine suspended clay was probably a factor delaying growth of bass in some ponds. Rooted aquatic vegetation was abundant enough to hinder fishing in only one pond, and did not seem to be a factor in determining the success of any pond.

Information gathered by the Swingle minnow seine technique was in fair agreement with that revealed by larger seines and by age studies. The Swingle technique was not always properly timed to detect young-of-year fish and did not always detect bullhead populations.

Winterkill was a major influence affecting population balance. Fish populations in 31 of the ponds suffered some degree of winterkill during their known history with kills of all the bass and all the bluegills occurring in 18 of the ponds.

Largemouth bass were in relatively poor condition compared with bass from other areas, but grew more rapidly than those from other Iowa impoundments and from several midwestern lakes. On the average, bass in Iowa ponds reached the legal length of ten inches and minimum spawning size during their third summer and probably spawned for the first time the following spring. Bass in newly stocked ponds grew more rapidly and usually spawned as two-year olds. Spawning occurred annually except in a few ponds.

Bluegills from the farm ponds were poor to average in relative plumpness. Growth of bluegills in ponds having balanced populations was generally good, total lengths at successive annuli being 1.7, 4.1, 6.1, and 7.0 inches. Growth in ponds not displaying balanced populations was noticeably slower. In new ponds bluegills usually reached spawning size at one year of age, but since growth in established ponds was slower, bluegills probably did not spawn until two years old. In some cases, young bluegills were not found until August.

White crappies seemed to reproduce almost annually in Iowa farm ponds. Crappies from two of the ponds were intermediate in plumpness when compared with those reported in other Iowa studies. Three growing seasons were usually necessary to produce crappies of harvestable size.

Ponds that were rated as successful gave population estimates for bluegills generally ranging from 100 to 400 pounds per acre. Ponds that were rated as unsuccessful gave estimates ranging from 30 to 75 pounds. Estimates of bass were obtained for only three ponds, and ranged from 18 to 96 pounds per acre.

Attempts to correct existing unbalanced populations by a supplemental stocking of bass or bluegills or both were generally not successful, usually because of winterkill. Rotenone treatment and subsequent restocking was generally successful in re-establishing fish ponds, even where bullheads were not entirely eliminated by the rotenone. One attempt to control a heavy population of white crappies by seining and removal resulted in greatly increased growth of the remaining crappies, but did not eliminate them or their reproduction.

THE BIOSYNTHESIS OF PYRIMIDINES BY MUTANTS OF AEROBACTER AEROGENES[1]

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The biosynthesis of pyrimidines by Aerobacter aerogenes NRRL #199 was investigated. Pyrimidine-requiring mutants of this organism which were produced through ultraviolet irradiation served as a valuable tool in analyzing the reaction sequence of pyrimidine biosynthesis in this organism.

The demonstration of recombination between certain pairs of mutants was attempted, in an effort to ascertain the nature of the genetic blocks through an analysis of the resultant progeny. However, recombination did not appear to occur in A. aerogenes NRRL #199.

Four distinct types of pyrimidine auxotrophs of A. aerogenes were produced. Type A mutants grew only on uracil, cytosine, or the corresponding nucleosides or nucleotides. Type B mutants utilized orotate in addition to these compounds. Type C mutants responded to ureidosuccinate, orotate, or uracil. The type D mutants utilized these compounds as well as aspartate. The latter mutant type also responded slightly to oxalacetate.

These observations are consistent with the following postulated biosynthetic reaction sequence:

$$\text{Oxalacetate} \xrightarrow{D} \text{Aspartate} \xrightarrow{C} \text{Ureidosuccinate} \xrightarrow{B} \text{Orotate} \xrightarrow{A} \text{Uracil}$$

Variations in temperature had no effect on the pyrimidine requirement. The response to the postulated uracil precursors occurred after a lag of 14-16 hours, and reached a maximum after incubation for 20-24 hours.

The accumulation of an intermediate previous to a given postulated genetic block could not be demonstrated. Syntrophy did not appear to occur when mutants were grown together. Uridylic acid was the sole pyrimidine compound which accumulated in the cells of the wild type or mutant organism under any of the conditions used. The presence of orotic acid riboside could not be demonstrated.

Various pyrimidine compounds accumulated in the supernatant when cultures of the wild type or mutant organisms were grown in minimal medium which had been supplemented with different pyrimidine compounds or postulated precursors. Mutants of types B, C, and D, as well as the wild type organism, accumulated uracil when grown in the presence of aspartate; the wild type cells and the types C and D mutants produced orotic acid and uracil in the presence of ireidosuccinate. The type B mutants and the wild type organism accumulated uracil when grown in a medium which contained orotate. Thymine and its derivatives were not converted to other pyrimidine compounds by the wild type organism, although methyl cytosine was readily converted to thymine. The mutant and wild type cells accumulated uracil in the presence of uridine or uridylic acid. Cytosine was converted to uracil; uracil, uridine, and uridylic acid were produced from cytidine. Growth on cytidylic acid resulted in uracil production. These results emphasize the central position occupied by uracil in the pyrimidine metabolism of A. aerogenes.

The conversion of orotic acid to uracil, or the conversion of ureidosuccinic acid to orotic acid and uracil could not be demonstrated with resting wild type cells.

Small amounts of uracil and uridine were shown to be produced by cell-free extracts of A. aerogenes in the presence of orotate; small amounts of orotate, uracil, and uridine were produced in the presence of ureidosuccinate. The significance of these results were discussed.

Mutants of miscellaneous types were also produced and collected. Some of these mutants responded to purines and to an enzymatic (desoxyribonuclease) digest of calf thymus. Others responded only to the desoxyribonucleic acid digest. These latter mutants may require a dinucleotide or more complex molecule for growth, since they did not respond to any of the desoxyribomononucleotides.

[1]Doctoral thesis no. 1515, submitted March 12, 1954. Chairman of Committee, C. H. Werkman, Department of Bacteriology.

[2]B.A., Augustana College, Sioux Falls, S.D., M.A., University of South Dakota, Vermillion, S.D., 1949. Graduate Assistant, Industrial Science Research Institute.

STEREOCHEMISTRY OF HYDROGEN BROMIDE ADDITION TO OLEFINS[1]

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The ionic addition of hydrogen bromide to olefins has been studied. Previous investigations of this reaction have been complicated by the use of compounds in which isomerism of the olefin or addition product is possible, or in which the participation of neighboring groups may direct the course of addition. The olefin selected in this study, 1,2-dimethylcyclohexene, did not have these disadvantages.

A knowledge of the structure of the isomeric cis and trans 1,2-dimethylcyclohexanols was necessary to assign structures to the products of the addition reaction. Pyrolysis of the acetates of these alcohols should give cis elimination of acetic acid to form mixtures of olefins. The trans 1,2-dimethylcyclohexyl acetate gave 2,3-dimethylcyclohexene and 2-methylenemethylcyclohexane. The cis 1,2-dimethylcyclohexyl acetate gave 1,2-dimethylcyclohexene in addition to the olefins given by the trans acetate. Hence, the assignment of configuration of these alcohols was correct. The fact that the predominant products in the pyrolysis of the cis and trans 1,2-dimethylcyclohexyl and 1-methylcyclohexyl acetates were exocyclic olefins was noted and discussed.

The elimination reactions of the products of hydrogen bromide addition, cis and trans 1,2-dimethylcyclohexyl bromides, were studied in order to aid in the determination of their configuration and to obtain a method of the determination of isomer ratios in their mixtures. The rates and the reaction products for the first order elimination of both the cis and trans bromides were found to be approximately the same. The first order rate equation was obtained for the cis and trans bromide in 98 per cent ethanol, abtolute methanol, and 55.4 mole per cent acetone in water at 25°. The first order rate constant was also obtained for 1-methylcyclohexyl bromide in the latter solvent at 25°, and did not differ appreciably from the values for the isomeric dimethyl bromides. The predominant product of the first order elimination reaction in the case of the 1,2-dimethylcyclohexyl bromides was 1,2-dimethylcyclohexene.

The rate and the reaction products of the second order elimination of the cis and trans 1,2-dimethylcyclohexyl bromides with sodium hydroxide in 98 per cent ethanol and of the trans 1,2-dimethylcyclohexyl bromide with sodium methylate in absolute methanol were obtained. The fast rate of the competitive first order elimination reaction rendered precise determination of the rate of the second order elimination reaction impossible in methanol. In 98 per cent ethanol manageable kinetics were obtained for the second order reaction. The cis bromide was found to have a second order rate one hundred times slower than the trans bromide. This was interpreted on the basis of the need of a planar transition state for the elements involved in trans elimination. The trans bromide gave only 1,2-dimethylcyclohexene as the elimination product in sodium hydroxide-ethanol solution. The cis bromide gave predominantly 2-methylenemethylcyclohexane rather than 2,3-dimethylcyclohexene, the product predicted by the Saytzeff rule. The anomolous formation of this olefin is discussed on the basis of a conformational analysis of the isomeric bromides. The steric requirements of the base in the second order elimination reaction of trans 1,2-dimethylcyclohexyl bromide were studied qualitatively. The bases used in this investigation were lithium aluminum hydride and the nitrogen bases, pyridine, 2-picoline, and 2,6-lutidine. The reaction product was predominantly 1,2-dimethylcyclohexene at 25° in each case. The amount of reaction occurring in a given time varied with the steric requirements of the base. Under forcing conditions isomeric olefins were formed.

The reaction of hydrogen bromide with the cis and trans 1,2-dimethylcyclohexanols was studied to find a method of preparation for the cis and trans 1,2-dimethylcyclohexyl bromides. To explain the results of this study, three reaction paths were postulated. The S_N1 mechanism accounted for most of the product in acetic acid. Some retention of configuration, by way of the S_Ni reaction, was detected in acetic acid with both the cis and trans alcohols. The reactions of cis 1,2-dimethylcyclohexyl acetate gave products indicating that alkyl-oxygen fission had occurred. In pentane at 0° or at -78° the S_Ni, the S_N1, and the S_N2 mechanisms may all operate. The S_Ni reaction predominates

[1]Doctoral thesis no. 1427, submitted June 22, 1953. Chairman of Committee, George S. Hammond, Department of Chemistry.

[2]B.S., Bradley University, Peoria, Illinois, 1947. M.S., Iowa State College, Ames, Iowa, 1951. Instructor. Associate, Industrial Science Research Institute.

at low temperatures. The reaction of the cis 1,2-dimethylcyclohexanol with hydrogen bromide at -78° served as a preparative method for cis 1,2-dimethylcyclohexyl bromide. The importance of the three mechanisms under the various experimental conditions was discussed.

The addition of hydrogen bromide to 1,2-dimethylcyclohexene in acetic acid at 25°, in pentane at 0°, and in pentane at -78° was investigated. In acetic acid at 25° an equilibrium mixture of the two bromides formed. Because the isomeric olefins, 2-methylenemethylcyclohexane and 2,3-dimethylcyclohexene did not give the same products, a stereo specific mechanism in addition to a classical carbonium ion mechanism must be postulated for the addition of hydrogen bromide to the three isomeric olefins in acetic acid. In pentane at 0° or -78° moderate concentrations of hydrogen bromide give pure trans addition. A concerted attack of hydrogen bromide on the hydrogen bromide-olefin complex was discussed as a path for this reaction. At high concentrations of hydrogen bromide in pentane at -78° some cis addition occurred. A cyclic mechanism was considered as a possible explanation for this addition.

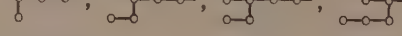
ACTION PATTERN OF SALIVARY AMYLASE[1]

PHILIP NORDIN[2]
Department of Chemistry

Amylotriose and amylotetraose were isolated from a salivary amylase-amylodextrin digest, using a carbon column. Crystalline 1-phenyl flavazole derivatives of both sugars were prepared. The hydrolyses of amylodextrin, amyloheptaose, amylotetraose, and amylotriose by salivary amylase were studied. The reactions were followed by paper chromatography and by determination of reducing sugar values. It was found that in the initial phase of the reaction, amylodextrin yielded maltose, amylotriose and amylotetraose. Amylotetraose was broken down largely to maltose at a rate about one-fourth that of amylodextrin. Amylotriose was hydrolyzed to glucose and maltose at a rate one one-hundredth that of amylotetraose.

Radioactive amylo-oligosaccharides were prepared by the coupling reaction of macerans amylase with alpha-dextrin and radioglucose. The products were shown to be labeled exclusively at the reducing glucose unit. The individual members, amylotriose to amyloheptaose, were hydrolyzed by salivary amylase, and the products at various stages of hydrolysis were separated by paper chromatography. An examination of the radioactivity and the reducing power of the hydrolytic products was made. The enzyme under normal conditions of temperature and pH hydrolyzed certain bonds preferentially. With the low molecular weight oligosaccharides examined the following generalization was found to hold: all bonds except the two terminal links and the link second from the nonreducing end are preferred by the enzyme. The two terminal links are extremely resistant to hydrolysis. The internal link second from the nonreducing end is hydrolyzed at a rate intermediate between that of other internal links and that of terminal links.

The singly branched dextrins remaining after extensive action (one thousand times the length of time required to reach the achromic point) of salivary amylase on waxy maize consisted of compounds having four, five, six, and seven glucose units. Separation of the dextrins as the 1-phenyl flavazole derivatives was achieved by paper chromatography in a solvent having the composition three parts of water, four parts of pyridine, and six parts of n-butanol. Partial degradation of the derivatives by acid hydrolysis and amyloglucosidase yielded hydrolytic products which could be identified by their characteristic R_f values. The following structures, based on these observations, were assigned to the major components of the dextrins;



[1]Doctoral thesis no. 1460, submitted October 3, 1953. Chairman of Committee, Dexter French, Department of Chemistry.
[2]B.S.A., University of Saskatchewan, Canada, 1949. M.S., Ibid., 1950. Graduate Assistant, Agricultural Experiment Station.

Evidence was presented that there were also produced doubly branched dextrins in the range of nine to twelve glucose units, which consisted of compounds with one glucose unit between branches.

ABNORMAL NUCLEOPHILIC ATTACK ON THE FURAN NUCLEUS[1]

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Attack in a nucleophilic displacement reaction is classified as being abnormal if the nucleophile is bonded to a different atom in the product than the atom to which the displaced group was bonded in the original molecule. Such abnormal attack has been found in the reaction of furfuryl halides with cyanide ion, in which the normal product, furfuryl cyanide, and the abnormal product, 2-methyl-5-cyanofuron, are obtained (1). In an attempt to discover other furfuryl derivatives which would react abnormally either with cyanide ion or other nucleophiles, furfuryl p-nitrobenzoate and furfuryl 2,4-dinitrophenyl ether were prepared. Neither of these compounds reacted with cyanide ion. Furfuryl 2,4-dinitrophenyl ether did not react with ethoxide or hydroxide ion. Furfuryl p-nitrobenzoate reacted with ethoxide ion in absolute alcohol to give p-nitrobenzoic acid. This result indicated abnormal alkyl-oxygen cleavage of the ester. The other product of such cleavage, ethyl furfuryl ether, could not be isolated. The abnormal cleavage could take place through the intermediate of a furfuryl carbonium ion which would give first order kinetics in the ester. A kinetic study of the reaction of furfuryl p-nitrobenzoate with hydroxide ion showed the reaction to be second order. This result indicates that a furfuryl carbonium ion was not in intermediate in the cleavage. Since the other product of abnormal cleavage, furfuryl ethyl ether, was not isolated, the possibility exists that p-nitrobenzoic acid was formed by some process other than abnormal cleavage.

In general, solid compounds are more easily prepared in a pure state and more easily checked for purity than liquids and so are suitable for kinetic and other studies. Since the furfuryl halides are unstable liquids, attempts were made to prepare solid furfuryl derivatives having reaction characteristics similar to the furfuryl halides. The preparation of the p-toluenesulfonate, p-bromobenzenesulfonate, and p-methoxybenzenesulfonate of furfuryl alcohol was attempted without success. A solid compound, 3,4-diphenyl-2-furfuryl bromide, m.p. 57°–58°, was prepared. The nitriles or the corresponding acids which would be expected to be formed by the reaction of this bromide with cyanide ion had not been prepared previously. The preparation of 3,4-diphenyl-2-furyl acetic acid was attempted unsuccessfully from 3,4-diphenyl-2-furoyl chloride by means of the Arndt-Eistert reaction. In another attempt to prepare this acid, 3,4-diphenyl-2-furfuraldehyde was condensed with rhodanine. The rhodanine compound was then cleaved with base to 3-(3,4-diphenyl-2-furyl)-2-thioketopropionic acid, m.p. 117°–118°. This thio-keto acid gave 3-(3,4-diphenyl-2-furyl)-2-oximinopropionic acid, m.p. 144°–145° on reaction with hydroxylamine. The substituted propionic acid was then treated with acetic anhydride in order to carry out simultaneous decarboxylation and dehydration to form the nitrile. This step was not successful. The other isomeric acid, 3,4-diphenyl-5-methyl-2-furoic acid was prepared by a Friedel-Crafts reaction of 3,4-diphenyl-2-furoic acid and methyl chloride. A complete structure proof for this compound was not made. Since so much difficulty was encountered in the synthesis of these compounds, this method of attack was abandoned.

In a further study of abnormal nucleophilic displacements, a theory proposed by Swain (2) was utilized. By application of this theory, Swain has been able to determine a relative numerical scale for nucleophilic activity of various reagents based on water as zero. This scale correlates well for many reactions. However, hydroxide ion is abnormally reactive with β-propiolactone, Attack by hydroxide ion takes place at the carbonyl carbon while other nucleophilic reagents attack at the alkyl carbon of β-propiolactone. The carbonyl carbon is an "unsaturated" reaction center while the alkyl

[1]Doctoral thesis no. 1512, submitted March 11, 1954. Chairman of Committee, George S. Hammond, Department of Chemistry.

[2]B.A., University of Colorado, Boulder, Colo., 1947. M.A., Ibid., 1950. Graduate Assistant, Industrial Science Research Institute.

carbon is a "saturated" center, which may explain the abnormal reactivity noted. In nucleophilic attack, the charge developed on the substrate is more dispersed in the case of attack at an "unsaturated" center than at a "saturated" center. Attack by a slightly polarizable ion such as hydroxide is aided more by charge dispersal in the substrate than is attack by polarizable ions. Since the reactions on which the scale of nucleophilic activity was based were at "saturated" centers, hydroxide ion appears to be abnormally reactive when reaction takes place at an unsaturated center.

Since the five positions of the furan nucleus in furfuryl chloride may be considered to be an "unsaturated" center, hydroxide ion would be expected to be abnormally reactive with furfuryl chloride if part or all of the reaction takes place in this position. Similarly, the slightly polarizable acetate ion would be expected to be abnormally reactive in such attack. However, a study of the kinetics of reaction of furfuryl chloride with water, acetate, iodide, thiosulfate, and hydroxide ions did not show any abnormal reactivity of hydroxide ion or acetate ion. This evidence indicates that with furfuryl chloride, attack by hydroxide or acetate ion does not take place at the five position of the furan nucleus.

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INFECTION OF ONION BY BOTRYTIS SPP.[1]

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An unusual spotting and blighting of the green leaves of red and yellow varieties of the common bulb onion, Allium cepa L., was observed near Garner, Iowa, in 1951. Similar disease symptoms were prevalent on yellow and white globe onions grown on the Holland-Bradford Marsh, Ontario, during 1952 and 1953. This foliage disease, incited by Botrytis squamosa Walker, and hitherto unreported in commercial onion fields of the United States and Canada, recently has been described on onions in England and France.

In the present investigation the causal relationship of B. squamosa with leaf spot and blight symptoms was studied. Inoculation experiments were performed in the greenhouse and in the laboratory. Onion leaves atomized with spore and mycelial suspensions of either B. allii, B. cinerea or B. squamosa and maintained under polyethylene bags in the greenhouse did not develop leaf spot. Leaf spot, similar to field symptoms was realized when onion leaves were atomized with inoculum of B. squamosa and incubated under controlled conditions in the laboratory. Leaf spot symptoms characteristic of naturally occurring lesions developed under conditions of free water on the leaves, intermittent periods of relatively low temperature, and a period of light.

Botrytis leaf spot and wilt is proposed as a descriptive and inclusive name for disease symptoms incited by Botrytis spp. on the green leaves of onions. The term "blast" would be retained for leaf spot and wilt symptoms of a physiogenic nature.

Damping-off of onion seedlings did not occur when onion seeds were germinated under a subirrigated peat mulch contaminated with different sources of inocula of B. allii, B. cinerea, and B. squamosa. However, when quartz sand was directly contaminated with mycelium of either of three neck-rot fungi or B. cinerea, a relatively high incidence of seedling damping-off occurred. Tip wilting of leaves resulted when onion plants were grown at any one of five different temperatures in quartz sand infested with one of four Botrytis spp.

Tests of certain foliar sprays in the field control of Botrytis leaf spot was begun in

[1]Doctoral thesis no. 1530, submitted May 26, 1954. Chairman of Committee, W.J. Hooker, Department of Botany and Plant Pathology.

[2]B.S.A., Ontario Agricultural College, Canada, 1949. M.S., Iowa State College, Ames, Iowa, 1951. Graduate Assistant, Agricultural Experiment Station.

1952 at the Holland-Bradford Marsh. This program was expanded and continued during the 1953 growing season. A weekly spray schedule was followed both years and the effectiveness of control obtained by the use of foliar sprays was evaluated by analyzing yield data. Significant increases in yields of onions were obtained by applications of Manzate, Parzate, or Vancide. Yields of onions in plots sprayed with Nu-Z, Nu-M, or DDT were significantly lower than in fungicide treated plots.

The effect of certain environmental factors, especially light, on sporulation, spore germination, mycelial growth and sclerotial formation by Botrytis squamosa were investigated.

Conidia produced in culture by isolates obtained from green onion leaves closely resembled the conidia of isolates of B. squamosa from white onion bulbs. These conidia did not germinate in distilled water in continuous light. A high percentage of germination occurred either in continuous darkness when the spores were suspended in distilled water, or in continuous light or darkness when onion tissue was present in the aqueous suspension.

Certain details of conidiophore development, particularly the accordion-like folds, diagnostic of this Botrytis species, are described. The production of conidia and other growth habits of the organism on different media were determined prior to investigating the effect of light on sporulation. Sporulation was most profuse when cultures of the organism on lima bean agar were exposed to 21 hours of light, preceded or followed by 3 hours of darkness. Two isolates of B. allii were found to be nonsporulating in continuous darkness at the end of 72 hours, while profuse sporulation occurred within the same period in continuous light.

Microconidia were produced in abundance at the interface of contiguous mycelia of certain isolates cultured together in single Petri dishes. Coiled hyphae of unknown function were commonly associated with microconidia produced at a mycelial interface between two colonies.

Mycelial growth of B. squamosa was inhibited by exposure to continuous illumination under an incandescent lamp. The inhibition was proportional to the intensity of the light. Inhibition of mycelial growth through a range of 75 foot candles of light intensity was greater than inhibition induced by a range in temperature of 5° to 25°C or a 25-fold increase in the level of d-glucose in the media. The thermal death point of the mycelium ranged from 38.5° to 39.5°C.

In culture, sclerotial morphology and frequency have been influenced by modifications in culture medium, incubation environment and by choice of the isolate of B. squamosa used. The formation of concentric rings of sclerotia was induced by either alternate exposure to light and darkness, or alternate exposure to temperatures of 10° and 25°C.

AN ACYLASE SYSTEM OF LACTOBACILLUS ARABINOSUS[1]

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The breakdown of certain acylamino acids by enzyme preparations from Lactobacillus arabinosus was followed by assaying microbiologically for liberated amino acids. In an experiment carried out at one enzyme concentration, a pH of 6.0, an ionic strength of .02 and .152 millemolar L-substrate concentration, the observed extents of hydrolysis of the L-substrates were as follows: benzoyl-L-leucine, 58 per cent; chloroacetyl-DL-leucine, 47 per cent; benzoyl-DL-methionine, 5.5 per cent; benzoyl-DL-valine, 1.3 per cent; and benzoyl-DL-phenylalanine, 1 per cent. Under the preceding conditions, carbobenzosyglycyl-L-leucine is almost completely hydrolyzed.

Acylase hydrolysis of the benzoylamino acids just mentioned and of carbobenzoxyglycyl-L-leucine was studied over the pH range 4.5 to 7.5 by use of a lyophilized enzyme preparation. The pH optima ranged from 5.65 to 7.1. No significant hydrolysis

[1]Doctoral thesis no. 1497, submitted December 15, 1953. Chairman of Committee, Sidney W. Fox, Department of Chemistry.

[2]B.S., University of Denver, Denver, Colorado, 1948. Graduate Assistant, Industrial Science Research Institute.

by the acylase system of L. arabinosus over the pH range of 4.5–7.5 and at rather high enzyme concentrations was detected for the following compounds: benzoyl-L-glutamic acid, benzoyl-L-aspartic acid, benzoyl-L-histidine, benzoyl-L-arginine, nor benzoyl-DL-threonine.

There was a close parallel between the rates of acylase hydrolysis and the, for the most part, previously reported nutritional utilizations of acylamino acids by L. arabinosus. Therefore, it is believed the utilization observations are due to the action or lack of action of an acylase system present in growing L. arabinosus.

The hydrolysis by a L. arabinosus acylase of benzoyl-L-leucine and carbobenzoyl-glycyl-L-leucine was inhibited by .0001 molar isocaproate and by .1 molar D-phenyl-alanine. No significant inhibition of acylase action was observed with .1 molar D-leucine, .1 molar D-valine, .01 molar 1-aminocyclobutane carboxylic acid, .01 molar 5-cyclobutane spirohydantoin, 1 mcg./ml. of penicillin G, 200 mcg./ml. of bacitracin. not 50 mcg./ml. of aureomycin.

The new compounds, N-phenylacetyl-1-aminocyclobutane carboxylic acid and N-benzoyl-1-aminocyclobutane carboxylic acid were prepared.

The activity ratios on benzoyl-L-leucine and carbobenzoxyglycyl-L-leucine for three different enzyme preparations from L. arabinosus which possessed considerably different activity per unit of protein was about the same. In view of this and the rather specific inhibition pattern for enzyme activity on the two named substrates, it seems likely that only one enzyme from L. arabinosus is responsible for the observed hydrolysis of benzoyl-L-leucine and carbobenzoxyglycyl-L-leucine. Since this enzyme does not break down benzoyl-DL-leucinamide, it probably is a carboxypeptidase.

Isocaproate failed to inhibit the growth of L. arabinosus in synthetic medium when leucine was furnished as L-leucine, but growth was inhibited when leucine was present only as benzoyl-L-leucine. It is believed that these observations make improbable the obligatory participation in protein synthesis of the L. arabinosus carboxypeptidase which hydrolyze benzoyl-L-leucine and carbobenzoxyglycyl-L-leucine.

DEVELOPMENT AND VALIDATION OF A VETERINARY MEDICAL APTITUDE TEST[1]

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Department of Veterinary Medicine

The ratio of the number of applicants to the number of students admitted into Veterinary Medicine has emphasized the importance of identifying the best qualified candidates for selection. The importance of such a selection has resulted in a careful examination of selection procedures.

The widespread use of aptitude testing for admittance to medical and other curricula suggested the use of such a test as a means of helping the admissions committees of Veterinary Medical schools with their selection. This study was initiated as a review and evaluation of the factors used for predicting the success of students enrolled in Veterinary Medicine and to develop an adequate aptitude test if such was so indicated.

The preliminary findings based on the records of 133 students enrolled in Veterinary Medicine at Iowa State College showed that chemistry and zoology were the best predictors of all courses taken in the first two pre-professional years. The correlation of the grade point average with chemistry was $r = 0.47$ and for zoology, $r = 0.41$.

The value of Form 20 of the Moss Aptitude Test for Medical Professions was determined by correlating the results of each sub-test with the grade point average obtained by students enrolled in Veterinary Medicine. Sub-tests entitled "Understanding of Printed Material" ($r = 0.38$) and "Comprehension and Retention" ($r = 0.22$) yielded the highest correlations.

As a result of these preliminary findings, it was decided to devise an aptitude test especially for Veterinary Medicine based upon material similar to the two sub-tests of

[1]Doctoral thesis no. 1482, submitted December 10, 1953. Chairman of Committee, E.A. Hewitt, Department of Veterinary Medicine.

[2]D.V.M., Kansas State College, Manhattan, Kans., 1941. M.S., Iowa State College, Ames, Iowa, 1947. Assistant Professor.

the Moss Medical Aptitude test which gave the highest correlations. Such a test was constructed and revised according to standard psychometric procedures. The test is entitled "Iowa Veterinary Medical Aptitude Test" and is composed of three sub-tests: Achievement test, Aptitude Test I or Paragraph Comprehension, and Aptitude Test II or Verbal Memory.

The current validation of this new test is based upon the cumulative grade point average of 260 students enrolled in five different schools of Veterinary Medicine. The test was taken by these students before enrolling in Veterinary Medicine, but the test results were in no way used in the selection of the students.

Discriminant function weights were established for each sub-test and a table of probability developed from these weights. This table predicts from the test results the chances out of 100 the student has of being in the upper quarter, the middle half or the bottom quarter of the class.

The value of this table was determined by predicting the position of 77 students who took the test, but whose results were not used in developing the probability table. These results show the test to be much more accurate in predicting those students who will fall in the lower quarter of the class than those who will be in the top quarter. This is to be expected as the students applying for admission into Veterinary Medicine are in a tightly restricted group to begin with.

Examination of other aptitude tests shows the Iowa State Veterinary Medical Aptitude Test to do as good a job at predicting success within veterinary medicine, if not better, than any other test yet devised.

USE OF INPUT-OUTPUT ANALYSIS IN ESTIMATING THE INTERDEPENDENCE OF AGRICULTURE AND OTHER ECONOMIC SECTORS[1]

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Input-output analysis was introduced by Wassily W. Leontief of Harvard University in a study of the interdependence of industries of the economy. His mathematical technique was used in this study to estimate the interdependence of agriculture and other economic sectors. Production coefficients were estimated and used to make an economic analysis of the effects of changes in demand and changes in the levels of net outputs. The objectives of the study were: 1. To formulate a mathematical model of input-output analysis of agriculture and other sectors of the economy. 2. To determine the adaptability of input-output analysis to agricultural production research directed at obtaining information on the interdependence between agriculture and the rest of the economy. 3. To provide an empirical illustration of the use of input-output analysis by estimating the parameters from statistics of agriculture and other sectors of the economy. 4. To analyze an empirical solution of an input-output model to obtain information on the interdependence of agriculture and other sectors of the economy. 5. To observe changes in input-output relations over time by use of input-output analysis. 6. To propose additional areas of production research where input-output analysis may be used in seeking solutions to economic problems.

The model of input-output analysis is a system of linear equations describing the flows of resources among the economic sectors.

$$X_i - \sum_{j=1}^{n} a_{ij} X_j = y_i \quad i = j \ (i = 1,2,---n) \qquad (1.1)$$

where X_i is the net output of the i-th sector; a_{ij} is the quantity of product of the i-th sector used by the j-th sector per unit of its net output; X_j is the net output of the j-th sector; y_i is the quantity of the i-th product included in the final bill of goods; and n is the number of sectors.

[1]Doctoral thesis no. 1436, submitted July 15, 1953. Chairman of Committee, Earl O. Heady, Department of Economics and Sociology.

[2]B.S., South Dakota State College, Brookings, S.D., 1942. M.S. Iowa State College, Ames, Iowa, 1951. Instructor. Cooperator, Agricultural Experiment Station.

The solution of the above system of equations provides the coefficients describing the interdependence between the final bill of goods and the levels of net output of the sectors.

$$\sum_{j=1}^{i} A_{ij} y_j = X_i \qquad (i = 1,2,\text{-----}n) \qquad (1.2)$$

where A_{ij} is the quantity of net output of the i-th sector due to y units of the j-th product included in the final bill of goods; y_j is the quantity of the j-th product in the final bill of goods; X_i is the level of net output of the i-th sector; and n is the number of sectors.

Data were collected from secondary sources and aggregated into five sectors of the United States economy: primary agricultural production, secondary agricultural production, industry and services, foreign trade, and government. Economic models were constructed from the data for 1949, 1939, and 1929.

An analysis was made of the effects of changes in the final bill of goods upon the flows of resources among the five economic sectors. The interdependence coefficients provide the basis for this analysis.

An analysis was made of the effects of changes in the net output of a sector upon the flows of resources among the sectors of the economy. The technical production coefficients provide the basis for this analysis.

Future changes in consumers' demand and levels of net outputs were assumed, and resource requirements of the sectors of the economy to accomplish these changes were estimated from the results of the study.

Primary agricultural production was dependent upon secondary agricultural production and industry and services. In 1949, a one dollar's worth of increase in the direct demand for primary agricultural products required a .06 and .42 dollar's worth of increase in secondary agricultural production and industry and services production, respectively.

Secondary agricultural production was dependent upon primary agricultural production and industry and services. In 1949, a one dollar's worth of increase in the direct demand for secondary agricultural products required a .70 and .44 dollar's worth of increase in primary agricultural production and industry and services production, respectively.

The interdependence of industry and services and agriculture indicates the effects of changes in derived demand for agricultural production. In 1949, a one dollar's worth of increase in the direct demand for industry and services products necessitated .10 and .08 dollar's worth of increase in primary and secondary agricultural production, respectively.

A 30 per cent increase in the net output of primary agricultural production in 1949 necessitated a 1.18 per cent increase in net output of secondary agricultural production, 1.02 per cent increase in net output of industry and services, and a .42 per cent increase in government services. A 38 per cent increase in the net output of secondary agricultural production in 1949 necessitated a 20.1 per cent increase in net output of primary agricultural production, a .45 per cent increase in net output of industry and services, and a .03 per cent increase in government services.

Input-output analysis of the economy for a number of consecutive years would furnish information on changes in structural relations caused by technological change or changing price relationships. This information would assist the scientist in predicting results of policies and determining policies to achieve ends in view.

HISTOLOGICAL AND CYTOLOGICAL CHANGES IN THE MAIZE EMBRYO DURING GERMINATION[1]

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The present investigation was undertaken to provide information on the histological and cytological changes which occur during germination of the corn kernel. The inbred and hybrid lines Os420, Os426, L289, I205, Os420 x Os426, L289 x I205, and the double-cross (Os420 x Os426) x (L289 x I205) were the lines studied. The use of inbreds, hybrids and the commercial double-cross was believed to provide material which would allow comparison of lines with different levels of vigor and would also permit detection of any consistent differences in mode of growth between the inbreds and their hybrids. The kernels were germinated in wet sphagnum at 30° ± 1°C. Collections were made at three hour intervals during early germination and at six and twelve hour intervals during later stages.

The imbibition of water into the dry kernel occurs principally through the pericarp, although part of the water enters the kernal through the spongy tissue of the broken pedicel. Openings are present in the cuticle over spaces between epidermal cells of the lower end of the coleorhiza. It is not known whether more rapid entrance of water is permitted through these pores.

The first external evidence of germination is the protrusion of the coleorhiza through the pericarp. The rupture of the pericarp is caused by the rapid elongation of cells of the coleorhiza, thereby causing sufficient pressure to be exerted to rupture the fruit coat at the base of the kernel.

A mechanical separation of the root cap from the tissue inside the tip of the coleorhiza occurs as a result of elongation of the coleorhiza before growth in length begins in the radicle.

The first mitotic divisions occur in the radicle approximately twenty-four hours after the beginning of imbibition. The first mitoses occur midway in the radicle and progress toward the root histogens. Soon thereafter, divisions occur in the first internode and progress upward throughout the plumule. Re-initiation of mitotic activity throughout the embryo requires six to eight hours after the first mitosis occurs in the radicle.

Early growth of the seedling involves the rapid growth of the primary and seminal roots and the erection of the plumule during the first thirty-six hours of germination; the most rapid growth of the coleoptile and leaves occurs from this time. Five leaves are present in the mature seed of all lines used, except one; only four foliage leaves are present in the inbred line I205. The first post-embryonic leaves are initiated at approximately sixty-hour intervals under the conditions of germination used.

During the first four days of growth, elongation of the first internode occurs, the first leaves become evident and an extensive primary and seminal root system is produced. During this time, most of the cells and tissues that were present in the mature kernel have become differentiated; further growth of the corn plant occurs through the production of new tissues by the meristems.

No mitotic activity occurs in the scutellum during germination; all cells and tissues present were produced before maturation of the kernel. Differentiation of the procambium strands in the scutellum occurs during germination. The median bundle and the larger branches are amphivasal in structure, and are comprised of scalariform tracheids, sieve tubes and parenchyma. Smaller ramifications of the vascular system are numerous in the upper part of the scutellum, but are less extensive in the lower part. No xylary elements are present in the vascular branches of the lower part of the scutellum.

The epithelial layer of the scutellum is composed of elongated cells which vary greatly in length from place to place in the epithelium. Much irregularity in surface contour is present; the deeper infoldings which have been called 'glands' are believed to be the result of uneven growth during the formation of the scutellum.

The bulk of the tissue of the scutellum is composed of irregularly ovoid parenchyma

[1]Doctoral thesis no. 1459, submitted August 19, 1953. Chairman of Committee, John E. Sass, Department of Botany and Plant Pathology.

[2]A.B., Colorado State College of Education, Greeley, Colo., 1949. M.S., Iowa State College, Ames, Iowa, 1951. Graduate Assistant, Industrial Science Research Institute.

cells that are similar in structure throughout the organ. Large simple pits occupy most of the contact area between cells. The nuclei of many of the parenchyma cells become deeply lobed during germination; occasional amitotic divisions occur by separation of one or more of the lobes.

The sequence of organ formation and tissue differentiation is similar in the embryos of inbreds and the hybrids used. Consistent differences in the inbreds and their hybrids which could be measured is limited to relative leaf number and the presence or absence of the anterior seminal root at any given time during germination. Differences in the degree of development of leaves and seminal roots, size differences in certain tissue systems, and differences in the degree of differentiation of cellular elements were evident in the embryos of inbreds and their hybrids. Some of these differences could be measured and treated statistically; other criteria, such as the degree of differentiation of tissues, are observable visually, but probably cannot be evaluated quantitatively.

It is believed that an evaluation of comparative growth of inbreds and their hybrids as to rate of development and differentiation of organs and tissues can be made by histological study. By use of a relatively vigorous inbred and a weak inbred, such as the inbreds Os420 and I205, respectively, and their hybrid, a critical evaluation of the inheritance of certain characteristics should be possible. Such evaluation would augment information obtained previously by the use of dry weights of developing corn kernels and excised embryos.

THE KINETICS OF THE REDUCTION OF PERCHLORATE ION IN DILUTE SOLUTIONS[1]

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Department of Chemistry

The reduction of perchlorate ion by Ti(III) in dilute solutions appears to proceed by several paths. The reaction has both H^+ dependent and H^+ independent paths. The addition of Cl^- retards the rate considerably at concentrations below 2M. This appears to be due to the formation of complexes of Ti(III) and Cl^-. At higher concentrations the reaction rate is independent of Cl^-. The rate of reaction is also first order in Ti(III) and ClO_4^-.

The rate of disappearance of Ti(III) in dilute perchlorate solution may be written,

$$-\frac{d[Ti^{+3}]}{dt} = k_1[Ti^{+3}][ClO_4^-] + k_2[TiCl^{++}][ClO_4^-]$$

$$+ k_3[Ti^{+3}][ClO_4^-][H^+] + k_4[TiCl^{++}][ClO_4^-][H^+].$$

By taking into account only the first chloride complex of Ti(III), i.e., $TiCl^{++}$, this rate equation can be written,

$$-\frac{d[Ti^{+3}]}{dt} = \frac{k_1 + k_2K_1[Cl^-] + k_3[H^+] + k_4K_1[Cl^-][H^+]}{1 + K_1[Cl^-]}$$

$$[ClO_4^-][Ti^{+3}],$$

where,

$$K_1 = \frac{[TiCl^{++}]}{[Ti^{+3}][Cl^-]}.$$

[1]Doctoral thesis no. 1504, submitted January 22, 1954. Chairman of Committee, Frederick R. Duke, Department of Chemistry.

[2]B.S., University of New Hampshire, Durham, N.H., 1949. M.S., Ibid., 1951. Research Assistant, Institute for Atomic Research.

This is the rate expression found from experiment.

The rate constants were determined at two temperatures and the activation energies and entropies were calculated.

The reaction is thought to proceed through the formation of a coordinated complex, the disproportionation of which is the rate determining step. The following equations have been proposed to explain the kinetics of the reaction.

$$Ti^{+3} + ClO_4^- \rightleftharpoons [complex] \longrightarrow ClO_3 + TiO^{++},$$

$$Ti^{+3} + H^+ + ClO_4^- \rightleftharpoons [complex] \longrightarrow ClO_3 + Ti(OH)^{+3},$$

$$TiCl^{++} + ClO_4^- \rightleftharpoons [complex] \longrightarrow ClO_3 + TiO^{++} (\text{or } TiOCl^+) + Cl^-,$$

$$TiCl^{++} + H^+ + ClO_4^- \rightleftharpoons [complex] \longrightarrow ClO_3 + Ti(OH)^{+3} (\text{or } TiOHCl^{++}) + Cl^-.$$

The radical ClO_3 reacts further in a series of rapid one electron transfer reactions to the final products, Cl^-.

THE INCORPORATION OF CARBON^{14} INTO LEAF AMINO ACIDS AND PROTEIN[1]

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With the aid of carbon-14, various studies on amino acid and protein metabolism have been carried out.

It was found that excision of soybean leaves resulted in a decreased uptake of labeled amino acids to form protein. By increasing the time between excision and exposure to $C^{14}O_2$, a more or less graded series of the ratio, amino acid-C^{14} to protein-C^{14}, could be obtained. In a series of experiments; one, four, eight, and twenty hours, excised leaves appeared to preferentially incorporate free glutamate-C^{14} into protein glutamate-C^{14}. This led to the conclusion that there was either a selectivity in protein turnover, or a net synthesis of glutamate-rich protein. An attempt was made to determine which mechanism was correct by the isolation of individual leaf proteins via paper electrophoresis.

A tobacco leaf, excised for 8 days, incorporated amino acid-C^{14} into protein at approximately two-thirds of the rate shown by an attached leaf. In this case, there was no preferential incorporation of glutamate-C^{14}. However, there was some indication that aspartate-C^{14} was preferentially incorporated in the attached leaf.

A leaf punch technique was used to obtain a statistically valid picture of amino acid turnover during photosynthesis in $C^{14}O_2$. The results indicated that both alanine and serine are rapidly turning over. However, glycine accounts for the major activity in protein following a 16 minute exposure to $C^{14}O_2$.

In order to study the metabolism of leaf glycine during photosynthesis, glycine-2-C^{14} was fed to a tobacco leaf for 4 hours. It was found that the methylene carbon is an effective precursor of leucine and phenylalanine as well as the nonessential acids; aspartate, glutamate, serine, and alanine. However, the similar administration of methylamine-C^{14} (hydrochloride) did not result in the labeling of any identifiable metabolite.

The phenylalanine-C^{14}, isolated from excised tobacco and soybean leaves, which had photosynthesized for one hour in $C^{14}O_2$, was degraded. The results indicated that the synthesis of the aromatic ring occurred in the leaf.

[1]Doctoral thesis no. 1455, submitted August 11, 1953. Chairman of Committee, S. Aronoff, Department of Botany and Plant Pathology.

[2]B.S., Hobart College, Geneva, New York, 1949. Graduate Assistant, Institute for Atomic Research.

A study was made of the amino acid and protein radioactivity formed in the dark by exposure of a soybean leaf to $C^{14}O_2$ for 20 hours. It was concluded that:

1. Protein synthesis or turnover occurred in the dark.
2. The branched chain and aromatic amino acids were not formed via dark fixation.
3. The ratios of activity in protein amino acids to free amino acids in the dark were different from those in the light.
4. The highest level of activity was found in arginine. Seventy-five per cent of this activity was in the guanida group. These facts pointed to an active "Ornithine Cycle" operating in leaves.

The preparation and properties of a homogeneous leaf-cell suspension were demonstrated. The results indicated the protein incorporating system of the leaf to be more labile than the photo-synthetic system.

Amino acid and protein synthesis in young leaves was studied. The results showed that expanding soybean leaves produced certain essential amino acids from $C^{14}O_2$ more rapidly than did mature leaves. The leucine thus formed was degraded and showed an essentially uniform distribution of C^{14}.

CATTLE GRUB CONTROL IN IOWA[1]

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The work described in this paper was carried out in two parts, each with its own distinct goal:

1. Are there increased rates of weight gain in feeder calves following the use of rotenone-bearing grub control sprays?
2. Will the daily application of synergized pyrethrins reduce grub infestations of native cattle in Iowa?

The first of these problems was attacked by treating calves monthly during the winter cattle grub months, weighing the calves individually, and comparing the weights of treated animals with those of similar untreated animals. When given a statistical treatment, the data showed that there was no significant difference between the weight gains of the treated and untreated animals.

The second problem was approached through the use of automatic treadle sprayers. A repellent solution containing 10 per cent piperonyl butoxide and 1 per cent pyrethrins was applied to herds of native cows and their calves. The two herds used were of the angus breed. Each herd was divided into two portions, one to use the sprayer and the other to be left untreated as a check group of animals. One of the groups to be treated used the automatic sprayer in the entrance to the salt corral in the pasture. The other sprayer was installed in the gate between a very good brome-alfalfa pasture and a poor bluegrass pasture in which the water source was located. Grubs becoming encysted in the backs of calves in the treated and untreated herds were counted, and some were removed for species determinations. These grub counts showed that the common cattle grub, Hypoderma lineatum, was reduced between 85 and 100 per cent in the calves from the herd using the sprayer set between the two pastures. In the same herd, H. bovis, the northern cattle grub, was not controlled. There was an overall reduction in grubs of 47.4 per cent. It appears that the difference in the effectiveness of the sprays against these two species of flies lies in the oviposition habits of the females. H. lineatum must spend considerable time on an animal while ovipositing, giving the spray a good opportunity to take effect, while H. bovis, using a bombing technique while laying eggs, is not affected by the repellency.

There was no difference between the grub counts made on the untreated animals and the calves from the herd using the sprayer placed in the entrance to the salt corral. It was determined that this was apparently due to the failure of the calves to go to salt since they receive their minerals through their mothers' milk at that age.

[1]Doctoral thesis no. 1535, submitted May 28, 1954. Chairman of Committee, H.M. Harris, Department of Zoology and Entomology.

[2]B.S., Iowa State College, Ames, Iowa, 1946. M.S., Ibid., 1950. Associate, Agricultural Extension Service.

STUDIES IN THE OXINDOLE SERIES[1]

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In two instances of the reported O-alkylation of simple oxindoles, the compounds were shown by infrared and ultraviolet spectrographic analyses to be C-alkylated oxindoles. The compound reported as 1-methyl-2-(β-dimethylaminoethoxy)-indole (1), obtained from the reaction of 1-methyloxindole with β-dimethylaminoethyl chloride in the presence of sodamide, was shown to have the characteristic oxindole carbonyl absorption band in the infrared spectrum, and had all the characteristics of a simple oxindole in the ultraviolet spectrum. This compound was therefore formulated as 1-methyl-3-(β-dimethylaminoethyl)-oxindole. Similarly the compound reported as 2,3-dihydro-8-methylfuro [2,3-b] -indole (2), formed by an intramolecular O-alkylation, was shown to he 1-methyl-3,3-dimethyleneoxindole resulting from an intramolecular C-alkylation.

The reported O-alkylation of 3-isopropyloxindole, via the reaction of its silver salt with methyl iodide (3), was shown to be incorrect due to faulty interpretation of the structure of the starting material which was apparently isovaleranilide rather than 3-isopropyloxindole, in which case the product obtained would be an O-alkylated anilide rather than an O-alkylated oxindole.

The product obtained by reacting the sodium salt of 1-methyl-3-hydroxymethyleneoxindole with methyl iodide, which was reported to be formed by an O-alkylation of this β-dicarbonyl system involving the carbonyl of the amide linkage (4), was shown, by a consideration of the infrared and ultraviolet spectra of the alkylation product and its catalytic reduction product, to have been formed by an O-alkylation involving the hydroxymethylene function. Therefore, the alkylation product is now formulated as 1-methyl-3-methoxymethyleneoxindole, and the reduction product from it as 1-methyl-3-methoxymethyloxindole. Chemically, these formulations were confirmed by the ozonization of the alkylation product which yielded 1-methylisatin.

A common degradation product of several oxindole alkaloids (5, 6, 7) with the empirical formula $C_{10}H_9ON$ was shown by analogy with 1-methyl-3,3-dimethyleneoxindole, both as to its formation and infrared and ultraviolet spectra, and by comparison with an authentic sample, to be 3,3-dimethyleneoxindole.

In connection with the development of a general synthesis of oxindoles involving the reduction of the corresponding dioxindoles, 3-isopropyldioxindole and 3-ethynyldioxindole were synthesized by the reaction if isatin with the appropriate organometallic compounds. However, catalytic reductive methods attempted to obtain the oxindoles were unsuccessful.

The formulations of the structure of the product resulting from the reaction of 1-methyl-3-hydroxymethyleneoxindole with sodium acetate in acetic anhydride (8, 9) were shown to be incorrect by analyses and by a consideration of the catalytic reduction of this compound which yielded 3-methylene-bis-(1-methyloxindole). However, no new structural assignment was made.

A study of the reaction of diazomethane with 1-methyl-3-hydroxymethyleneoxindole indicated that O-alkylation at either of the possible sites could occur depending on the solvent used, so that using ether as the solvent, 1-methyl-2-methoxy-3-formylindole was formed while 1-methyl-3-methoxymethyleneoxindole resulted from the reaction using methanol as the solvent.

A general method for the 3-monoalkylation of 1-alkyloxindoles was developed. This process involves prior formation of the anion of the oxindole from the reaction of the oxindole with an equivalent amount of sodium hydride in benzene, followed by reaction with the appropriate alkyl halide. Using this method, 1,3-dimethyloxindole, 1-methyl-3-(β-bromoethyl)-oxindole and 1-methyl-3-(β-dimethylaminoethyl)-oxindole were synthesized.

A proposed general synthesis of O-alkylated oxindoles, involving the reaction of 2-haloindoles with appropriate anions, necessitated the development of a general synthesis of 2-haloindoles. However, the reaction of 1-methyloxindole with thionyl chloride yielded a highly colored, apparently dimeric product rather than 1-methyl-2-chloro-

[1]Doctoral thesis no. 1561, submitted June 7, 1954. Chairman of Committee, Ernest Wenkert, Department of Chemistry.

[2]B.Sc., University of Alberta, Canada, 1946. Graduate Assistant, Industrial Science Research Institute.

indole, while the reaction of 3-isopropyloxindole with phosphorus pentachloride resulted in chlorination in the 3-position to yield 3-chloro-3-isopropyloxindole.

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PRESENT STATUS AND OPINIONS OF GRADUATES GRANTED BACHELOR OF SCIENCE DEGREES SINCE 1932 IN AGRICULTURE CURRICULA AT IOWA STATE COLLEGE[1]

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One of the major objectives of Iowa State College is to provide the education necessary for leadership in the agricultural industry. The major emphasis in this respect occurs in the Division of Agriculture. During the 21-year period ending with the 1951-1952 school year, 4,439 students in the division of agriculture were granted baccalaureate degrees. Of these graduates, 65 completed curricula which since have been discontinued. These graduates were not included in the study. There were an additional 239 graduates of the industrial education curriculum who were not included in the study because of the remote connection of this curriculum to agriculture. Included in the study were 348 graduates of the agricultural engineering curriculum jointly administered by the Division of Engineering and the Division of Agriculture. Thus there were 4,483 graduates of thirteen curricula for whom a follow-up study was designed.

A questionnaire was prepared and sent to these graduates. In all, 4,199 questionnaires were deliverable and 3,593 usable returns were received. Approximately three in every four graduates were residents of Iowa at the time they first entered college.

Farm-reared boys constituted 62 per cent of the graduates with one in every four returning to the farm directly after graduation. The proportion of farm-reared graduates varied from a low of 24 per cent in forestry to a high of 86 per cent in agricultural education.

Of the 3,593 graduates, 1,165 persons, approximately one in every three, entered the Division of Agriculture after previous college work elsewhere. Approximately one in every five graduates transferred to an agricultural curriculum from some other division at Iowa State College.

The majority of the graduates had their college education interrupted by work or military service, or both. Of these individuals graduating since 1947, two in every three had their education interrupted by military service. Prior to this time military interruptions were few in number, but approximately one-half reported work interruptions during their college careers.

There were 392 graduates who later received one or more earned graduate degrees, usually the master of science or doctor of philosophy degree. Of this number, 71 individuals had been granted the doctor of philosophy degree. This degree had not been received at the time of this study by any graduate of the last three years of the 21-year period. Because the graduates of these three years constitute about one-third of the total group and because the graduates have had insufficient time for obtaining this

[1]Doctoral thesis no. 1429, submitted July 3, 1953. Chairman of Committee, James E. Wert, Department of Vocational Education.

[2]B.S., Iowa State College, Ames, Iowa, 1941. M.S., Ibid., 1947.

degree, the 71 of the 3,593 graduates who have obtained the doctorate is an underestimate of the proportion who will eventually receive this degree.

At the time of this study, 470 graduates, or 13 per cent, listed their present occupation as education, not including extension service. Of these 470 graduates, 179 individuals were teaching vocational agriculture in high school. 16 others were teaching veterans classes in agriculture; and the remaining 152 graduates, with few exceptions, were college staff members engaged in teaching or research, or both.

Graduates engaged in extension services were classified separately from other educational workers and numbered 175, or 5 per cent of all graduates. Of these 175 graduates, county extension directors numbering 76 persons were followed by state extension service numbering 65 persons with county youth assistants and assistant county directors accounting for 33 persons. One graduate was employed in federal extension service.

There were 470 graduates, or 13 per cent, in government service, one-third of whom were in the United States forest service. This large number in forest service was not unexpected since the forestry curriculum, among the thirteen considered in this study, accounted for more graduates than any other curriculum, except animal husbandry.

In 1952 there were 702 graduates, or approximately 20 per cent, who were engaged in farming. It has been previously noted that 62 per cent of the graduates had been farm-reared. This migratory effect of a college education in agriculture should not be viewed as unfortunate. The agricultural economy of this country would soon be bankrupt if all farm-reared boys were forced to return to farming. The demands for personnel in the agricultural industry, other than farming, have been so acute that agricultural colleges have recognized that maximum service to agriculture cannot be attained without stressing the opportunities for farm-reared youth in occupations other than farming in the total agricultural industry.

In 1952, enterprises other than farming provided occupational outlets for 1,296 graduates of whom 968 were in commercial agricultural enterprises, 123 in commercial nonagricultural enterprises and 205 in small business ventures.

The foregoing classifications of 1952 occupations account for all except 480 graduates who have been placed in a group designated as others. More than half (267) of these were in military service at the time of this study. An additional 88 individuals were continuing education as graduate students. The remaining graduates were employed in nonprofit organizations, miscellaneous farm and nonfarm services and a small additional number in a variety of occupations which occurred so infrequently that further classification was impractical.

In addition to the 1952 occupations, the occupations immediately upon graduation were obtained. Several shifts between first and present occupation were clearly evident even though many persons were recent graduates. Perhaps the most striking of these shifts was noted in the number engaged in farming. Of the 3,593 graduates, 483 individuals returned to the farm directly upon graduation whereas 702 graduates were farming in 1952. This migration tendency may have resulted from inadequate capital for immediate entrance into farming. It is probable that many of the 219 graduates were delayed from entering farming until sufficient capital could be accumulated although no evidence was collected to support this contention.

A similar shift was noted among graduates who were engaged in small business. On the other hand, certain initial occupations seemed to serve as stepping stones to later occupations. In this respect the migration from education, extension and government service was particularly noticeable.

One method of evaluating the effectiveness of a college education consists of recording the earned income of graduates. Although such evaluation may leave much to be desired, it constitutes one facet of tangible evidence. Of the 3,593 graduates who returned questionnaires, 3,115 individuals furnished income information. Graduates were asked to distinguish between income from major job and income from other sources such as investments, inheritance and other minor sources. Only the income from major job was analyzed. The total income for the 3,115 graduates was $16,413,000 for 1952, with a mean of $5269 and a median of $4586.

More than one-half of the 3,593 graduates received the bachelor of science degree since World War II. Many of the recent graduates were in graduate school at the time the data were collected. Of the 3,115 graduates reporting 1952 income, 111 individuals earned less than $2500 which in many cases represented income from fellowships and part time teaching assignments accompanying further education toward advanced degrees.

For the remaining 3,004 graduates the mean income was $5415 and the median income was $4800 in 1952. The mean income must be interpreted in the light of the disproportionate number of graduates since World War II who were in the process of occupational establishment in 1952.

When the mean income was plotted by year of graduation, an upward trend in income was apparent depending upon the number of years since graduation. The equation for the straight line trend, found by the method of least square, was $Y = \$202.5907 + \$3582.46$, where Y is the predicted mean income and X is the number of years since graduation. This linear equation tended to yield an overestimate for recent and early graduates and to yield an underestimate for graduates of the middle years of the 21-year period.

A quadratic was assumed to be a more realistic equation. The equation, $Y = -4.8353X^2 + 298.2733X + 3300.55$, was obtained by the method of least squares. When this equation was solved the mean annual income increments were unequal, varying from $284 between the first and second years to $100 between the twentieth and twenty-first years. This equation suggests that the mean annual income will reach a maximum of $7900 at 30 years and 10 months after graduation.

Graduates with master's degrees received $400 greater annual income than those without such degrees. Graduates holding the doctorate received an additional $800 annual income. The ultimate earning power of individuals with advanced degrees probably would be larger if information could be assembled for each individual when he had reached his peak income.

Among thirteen occupations, beginning income, based upon 1952 standards, was highest ($4750) for graduates engaged in small business enterprises and lowest ($3297) for those engaged in research work. Twenty years after graduation, the highest income ($9558) can be expected in industrial management and the lowest ($4781) in teaching vocational agriculture.

Responses to the items included in the questionnaire clearly revealed that the graduates in agriculture at Iowa State College have received the education needed for leadership in the agricultural industry.

MOVEMENTS OF SOIL MOISTURE UNDER A THERMAL GRADIENT[1]

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A number of investigators have shown that moisture movement in soil occurs on the application of a thermal gradient. A review of pertinent references on this subject shows that there is considerable disagreement, not only as to the nature of the mechanism responsible for this movement, but also as to the amount and relative importance of such a movement.

In this thesis an analysis of the movement of moisture under a thermal gradient is made for a closed system. This analysis shows that any movement of moisture in the liquid state from the warm to the cold side eventually ceases. It is further shown that with respect to vapor flow, it is impossible to get an equilibrium state without a cyclic transfer of mass. That is, moisture moving from the warm side toward the cold side in the vapor state is returned to the warm side in the liquid state when a sufficient capillary potential gradient is developed in that direction.

At moisture contents below the field capacity a number of investigators have shown that capillary movement is a very slow process. By providing an external path between the warm and cold ends, whose resistance to flow is considerably less than the resistance of the capillary flow in the soil, a quantitative measurement of vapor flow during steady state conditions can be obtained for moisture contents between field capacity and that corresponding to a tension of one atmosphere. An apparatus based on these principles is developed and described in this thesis.

[1]Doctoral thesis no. 1565, submitted June 8, 1953. Chairmen of Committee, M. A. Spangler, Department of Civil Engineering, and Don Kirkham, Department of Agronomy.

[2]B.S., Utah State College, Logan, Utah, 1941. M.S., Ibid., 1948. Assistant Professor. Cooperator, Engineering Experiment Station.

In the closed system, which has been subjected to a thermal gradient, the moisture accumulation in the cold end includes accumulation resulting from both liquid and vapor movements. In a closed system where vapor is allowed to circulate, no accumulation due to vapor movement can occur. Thus, if the moisture distributions for the noncirculating system are compared with those for the circulating system, some indication of the relative importance of vapor movement versus liquid movement should be obtainable.

A loess soil from western Iowa with a textural classification of a silty clay was used in these experiments. Comparisons of moisture distributions for circulating and noncirculating systems were made for per cent air-filled voids varying from about 50 to 8 per cent. In all cases these comparisons showed that in noncirculating systems moisture accumulated in the cold side and that in circulating systems essentially no accumulation occurred.

Flow rates were determined for temperature differences of 0°–10°C, 0°–20°C, 0°–30°C, and 0°–40°C for a number of different values of per cent air-filled voids. These results show that the flow rate is not a linear function of the temperature difference. They further show that the rate of change of the flow rate with respect to the temperature difference decreases sharply with a reduction of the per cent of air-filled voids.

A plot of flow rate versus the per cent of air-filled voids was determined for the temperature differences stated above. The flow rate appears to be a linear function of the per cent of air-filled voids.

A formula based on molecular diffusion is presented for the estimation of flow, assuming a molecular diffusion process. Values of the flow rate are computed using diffusion coefficients and a structure factor taken from the references on this subject. Measured values were found to be several times as large as values computed on the basis of pure molecular diffusion. The reason for the disagreement between computed and measured results cannot be ascertained from the data at hand.

Regardless of the difference between computed and measured values of the flow rate it is believed that the experimental results obtained lend support to the belief that the predominant mechanism of moisture migration under a thermal gradient is associated with vapor movement. It should be pointed out, however, that the soil used here was a silty clay, and that more experiments should be carried out with heavy clays to establish completely the validity of the above statement.

HERIDITARY ASPECTS OF GYNANDROMORPH OCCURRENCE IN HONEY BEES (APIS MELLIFERA L.)[1]

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Bees that are some combination of male and female tissues (called sex mosaics or gynandromorphs) were found in considerable numbers in one of the Iowa State College honey-bee colonies on September 2, 1948. Genetic studies using eye-color mutations as marker genes established, with very few exceptions, that chromosomes of male parts of the gynandromorphs were derived from the male parent, whereas chromosomes of female parts were derived from both parents. Apparently the male parts result from survival of one or more accessory sperms which enter the egg and undergo cleavage. The female parts presumably result from cleavage of the zygote. Previously it had been shown that accessory sperms normally enter the egg of the honey bee, and it has been assumed that such sperms invariably degenerate.

The tendency to produce gynandromorphs now has been investigated to determine whether it has a hereditary basis and, if so, whether this basis is in the chromosomes, in the cytoplasm, or partly in each. Three types of matings were made: (1) females (queens) of the gynandromorph-producing stock by males (drones) of the gynandromorph-

[1]Doctoral thesis no. 1555, submitted June 4, 1954. Chairmen of Committee, O.W. Park, Department of Zoology and Entomology, and John W. Gowen, Department of Genetics.

[2]B.S., Iowa State College, Ames, Iowa, 1950. M.S., Ibid., 1952.
Associate, Agricultural Experiment Station.

producing stock, (2) females of the gynandromorph-producing stock by males of non-gynandromorph-producing stock followed by backcrossing female progeny to males of the paternal stock, and (3) reciprocal of (2).

In the first type of mating, 58 females of gynandromorph-producing stock were artificially inseminated with semen from males of gynandromorph-producing stock. Twenty-nine queens produced one or more gynandromorphs. Selection and inbreeding for four generations increased the percentage of queens which produce gynandromorphs. Occurrence of gynandromorphs, consequently, seems to have a hereditary basis.

In the second type of mating, 53 females of the gynandromorph-producing line (or partly from the gynandromorph-producing line) were outcrossed to drones of non-gynandromorph-producing lines. Twenty-four of these queens produced gynandromorphs. Approximately the same percentage of these matings produced gynandromorphs as in the system wherein both females and males were from gynandromorph-producing stock. Daughters of the outcross were backcrossed to drones of non-gynandromorph-producing stock. Some of the first backcross matings produced gynandromorphs. Some matings in the second backcross (daughters of the first backcross mated to drones of non-gynandromorph-producing stock) produced gynandromorphs. No gynandromorphs were observed in the progress of 18 third-backcross queens, thus indicating a loss of the tendency for gynandromorph production brought about by this type of mating. The tendency to produce gynandromorphs, therefore, must be dependent, at least in part, on genetic components in the chromosomes.

In the third type of mating, females of non-gynandromorph-producing lines were mated to drones of the gynandromorph-producing line. No gynandromorphs were observed in the progenies of 29 such outcrossed queens. The difference in gynandromorph production by reciprocal outcrosses (in the second and third types of matings) establishes that gynandromorph production is regulated by the cytoplasm, but it does not establish that there are hereditary components in the cytoplasm which complement those in the chromosomes. Perhaps there is only a chromosomal conditioning of the cytoplasm which then leads to gynandromorph production. If there are no cytoplasmic components in the inheritance system, backcrossing daughters of the third type of mating to drones of the gynandromorph-producing line should invariably lead toward gynandromorph production. Second and third backcrosses might be expected to establish it. Such backcrosses were made in two different experiments, only one of which is considered here, but the data are not sufficiently extensive to permit sound conclusions. No gynandromorphs were observed in the progenies of 13 first-backcross queens. A few gynandromorphs were produced by three of twelve queens in the second backcross. Two of three third-backcross queens have produced one gynandromorph each. By comparison this is very low production of gynandromorphs, but it would seem to indicate that gynandromorph production may have been introduced into a non-gynandromorph-producing line by simply replacing the chromosomes of a non-gynandromorph-producing line with those from the gynandromorph-producing line, or in other words, by mating queens of the former to drones of the latter.

Results of the investigations described indicate that occurrence of gynandromorphic honey bees is due to inherited factors, and that these factors are located, at least in part, in the chromosomes. Although reciprocal crosses of gynandromorph-producing stock do not behave alike in gynandromorph production, there is as yet no evidence for either autonomous or chromosome dependent cytoplasmic factors in the inheritance of gynandromorph production.

INHERITANCE OF RESISTANCE IN CORN TO THE EUROPEAN CORN BORER AND TO DIPLODIA STALK ROT[1]

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Inheritance studies on resistance to the first brood of the European corn borer and resistance to diplodia stalk rot were conducted during 1950 and 1951 at Ankeny, Iowa. Corn was artificially infested with corn borer eggs while in the whorl stage. Data were taken on leaf feeding within two to three weeks after infestation on a rating scale of nine classes, and damage points on leaf sheaths, leaf midribs, and stalks were counted approximately six weeks after infestation. The stalks were inoculated with diplodia during the latter part of August and data were taken on the amount of spread of the stalk rot on a rating scale of nine classes about five to six weeks after inoculation.

Data on the three attributes, leaf-feeding ratings, damage-point counts, and diplodia stalk-rot ratings were taken on an individual plant basis on the following experiments: on Experiment I in 1950 which consisted of 9 inbreds and their 36 F_1's and F_2's, on Experiment II in 1951 which consisted of 7 inbreds and their 21 F_1's and on Experiment III in 1951 which consisted of $P_1, P_2, F_1, F_2, F_3, B_1, B_2, B_1S$, and B_2S populations of four crosses. Experiment I was designed to be analyzed by the method of constant parent regression and method of partitioning the variances of the F_2 into heritable and non-heritable portions. Experiment II was designed specifically for analysis by the method of constant parent regression and Experiment III by Mather's method of simultaneously estimating the D, H, E_1, and E_2 components of variation over all populations obtained from one cross. By the use of Mather's method the data could be tested for disturbances due to linkage; and the additive genetic variance, total genetic variance and the environmental variance and their standard errors could be calculated for the various population statistics.

Scaling tests were used to test the assumptions concerning genotype-environmental interaction and additivity of loci effects. Data on damage-point counts and diplodia stalk-rot ratings showed significant correlations between means and variances of inbreds and F_1's indicating the presence of genotype-environmental interactions. The environmental variance of damage-point counts was stabilized by the use of Beall's transformation for contagious distributions, and the $x + 1/2$ was used to stabilize the environmental variance of stalk-rot ratings. Significant deviations from additivity were present which could not be eliminated by transformations, however the possibilities of epistasis were taken into account in the interpretation of the results.

The results obtained from Experiments I and II were not of much practical use. The values obtained for the per cent heritable variation of the F_2's ranged from fairly large negative values to large positive values. Negative values are, of course, impossible but the design of the experiment did not permit the calculation of standard errors so as to provide a measure of reliability of the estimates. The results obtained from the constant parent regression did not provide a good index of the results obtained from segregating populations.

The results for leaf-feeding resistance indicated that effectiveness for individual plant selection would be low and that selection would have to be carried to progeny rows. For example, the per cent of genetic variance of the F_2 of each of the four crosses in Experiment III for leaf-feeding resistance was 42.1 ± 7.3, 38.5 ± 12.6, 23.3 ± 11.2, and 21.5 ± 12.6; whereas the per cent genetic variance of the F_3 means of the same crosses was 79.3 ± 15.8, 55.3 ± 29.0, 45.4 ± 29.4, and 56.2 ± 36.5, respectively. The per cent genetic variance of the backcrosses in comparison to that of their progeny rows showed the same relationship and indicated that alternate backcrossing and selfing would be more effective than straight backcrossing in transferring resistance to a susceptible inbred. The gene action involved in leaf-feeding resistance appeared to be mostly additive gene action with dominance and epistatis important in certain crosses.

The environmental variance accounted for practically all the variation of damage-point counts in the crosses studied. For example, the per cent genetic variance of the F_2 of each of the crosses in Experiment III was 10.6 ± 7.7, 8.7 ± 13.1, 10.8 ± 9.7, and

[1]Doctoral thesis no. 1524, submitted April 29, 1954. Chairman of Committee, G.F. Sprague, Department of Agronomy.

[2]B.S., University of Minnesota, Minneapolis, Minn., 1948. M.S., Iowa State College, Ames, Iowa, 1950. Graduate Assistant, Agricultural Experiment Station.

-0.51 ± 8.1; and the per cent genetic variance of the F_3 means of the same crosses was 50.6 ± 18.8, 7.1 ± 32.7, 48.8 ± 25.2, and 8.5 ± 32.7, respectively. Selection for resistance to the first brood of corn borers on the basis of damage-point counts would be very ineffective. A special experiment showed that the migration of the borers may affect the number of damage points per plant and, therefore, cancel out differences due to the survival rate of the borers.

The results for diplodia stalk-rot resistance were similar to those obtained for leaf-feeding resistance and indicated that effectiveness of individual plant selection would be low and that selection should be carried to progeny rows. For example, the per cent genetic variance of the F_2 of each of the crosses in Experiment III was 31.6 ± 10.4, 52.2 ± 15.1, 36.7 ± 8.0, and 31.9 ± 11.5, whereas the per cent genetic variance of the F_3 means of the same crosses was 55.5 ± 24.3, 51.5 ± 30.7, 80.0 ± 20.4, and 69.6 ± 31.4, respectively. Diplodia stalk rot involves additive gene action and dominance and possibly epistasis. The results obtained were contingent on the rating scale used and possible inadequacies of the stalk-rot rating scale were discussed.

Breeding for leaf-feeding resistance to corn borers and resistance to diplodia stalk rot were discussed. Because of the gene action involved and the relatively low genetic variances, recurrent selection was suggested as the most effective way of increasing gene frequency for resistance to corn borers and diplodia stalk rot. An alternate backcrossing and recurrent selection method was suggested for transferring a quantitative character such as leaf-feeding resistance and diplodia stalk-rot resistance from a resistant inbred to a susceptible inbred.

PROFILE PROPERTIES OF A LOESS-DERIVED WIESENBODEN SEQUENCE OF SOUTHEASTERN IOWA[1]

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Department of Agronomy

The loess-derived Wiesenboden soils of southeastern Iowa which include the Garwin, Taintor, and Haig series were studied in the field and laboratory. These soils are developed from Wisconsin Loess which thins exponentially in a southeasterly direction from near the central part of the state. Previous studies have shown a functional relationship between soil characteristics and the loess distribution pattern, particularly the loess thickness and the distance from the loess source.

The state soil association map indicates gradational boundaries between the soil association areas of which the Garwin, Taintor, and Haig series are members. Though distinct variations in profile characteristics are readily apparent when these series are studied at wide intervals, the differences tend to decrease as the profiles are observed at closer intervals. Soils with minimal or maximal characteristics of the series, varying from the central concept, occur at the soil association boundaries. Deviations or exceptions to the general relationship sometimes occur due to the effect of local but important factors.

Field studies were made of the Taintor and Haig series at their boundary in Jefferson County. Laboratory data concerning physical and chemical characteristics of nine profiles, four each of the Taintor and Haig series and one of the Garwin series, are discussed. The profiles of the Taintor and Haig series were selected to represent soil conditions at the series boundaries as well as of the central concept of the series.

The Taintor soils included those soils of poor natural aeration with a medium to heavy silty clay loam A_1 horizon (33-40 per cent 2 micron clay) and moderate horizon differentiation to the B_2 horizon of light to medium silty clay (42-45 per cent 2 micron clay). In contrast, the Haig series included soils with an A_1 horizon of light silty clay loam or heavy silt loam texture (26-31 per cent 2 micron clay) and strong horizon differentiation to the medium silty clay B_2 horizon (46-50 per cent 2 micron clay). The Garwin profile had a light silty clay loam A_1 horizon (less than 31 per cent 2 micron

[1]Doctoral thesis no. 1556, submitted June 4, 1954. Chairman of Committee, Frank F. Riecken, Department of Agronomy.

[2]B.S., State College of Washington, Pullman, Wash., 1936. M.S., University of Wisconsin, Madison, Wisc., 1937. Collaborator, Agricultural Experiment Station.

clay) and moderate horizon differentiation to the B_2 horizon at the silty clay loam-silty clay boundary (41 per cent 2 micron clay). The Taintor profiles were found to be less acid then the Haig with the pH reaching neutrality in the middle to lower part of the solum while the entire solum of the Haig profiles remained acid. The Garwin profile was more acid than the Haig profile.

The distribution of Taintor and Haig soils in Jefferson County indicated that Taintor soils occur on the broader tabular divides in the northern part and in local areas on the centers of the divides in the southern part. Haig soils occur on narrower divides and side branches. The probable occurrence of depressional areas in the Kansan till surface underlying local Taintor areas has been revealed. The width of the tabular divides and the configuration of the Kansan till surface affect the movement of water through the profile and appear to be important factors controlling the occurrence of Taintor and Haig soils at the soil association boundary.

The Garwin profile was highest, Taintor profiles intermediate and Haig profiles lowest in aeration porosity per cent. The order of the series for pH values and for per cent base saturation was Garwin lowest, Haig intermediate, and Taintor highest. These properties are related to the degree of leaching of the profiles, and in turn related to the loess thickness, restrictions on subdrainage as affected by Kansan gumbotil, width of tabular divides, and later movement of water to the drainageways.

For the ratio of exchangeable calcium to exchangeable magnesium the order of series is from the Garwin with the highest ratio to the Haig with the lowest. This ratio is a possible indication that the Haig profiles are the most weathered and the Garwin profile the least weathered with regard to calcium minerals. The Haig profiles have a lower per cent saturation of the exchange capacity with calcium than do Taintor and Garwin profiles, and the Garwin profile has a lower per cent saturation with exchangeable magnesium than do the Taintor and Haig profiles.

The carbon and nitrogen contents are essentially similar for the Garwin, Taintor, and Haig profiles studied.

NATURAL MUTATIONS IN INBRED LINES OF MAIZE AND THEIR HETEROTIC EFFECT[1]

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Dominance and/or overdominance are currently and commonly the two hypotheses advanced for explaining the heterosis phenomenon. Superiority of the heterozygous genotype over both homozygous classes at a single locus with a homozygous genetic background would be evidence for one type of overdominance.

A number of mutations with conspicuous phenotypic effects, which occurred in long time inbred lines of maize, were collected and maintained. All except one of the mutations were recessive. Each mutant line was crossed with the parental original inbred line to produce the Aa genotype which then was compared with the AA (original line), and in some cases also with the aa genotype (mutant line). Seed for 14 mutants was available and these mutant tests were grown in randomized block experiments in 1952 and 1953. One mutant test was grown in both years. Poor stand and heterozygosity of expected homozygous parents reduced the number of analyzed mutants to 12. The following attributes were recorded on an individual plant basis: plant height, number of seeds (1952) and 100 kernel weight (1953), total kernel weight, kernel row number and ear length. In one mutant, leaf width, number of tassel branches and ear diameter were also recorded. All data were transferred to IBM cards to facilitate calculations. An analysis of variance was carried out for each attribute in each of the mutant tests, and three of the attributes were chosen to be combined into a discriminant function. Analyses of variance for each discriminant were presented. A comparison of misclassification frequency of the discriminant and each individual attribute was based on

[1]Doctoral thesis no. 1503, submitted January 14, 1954. Chairman of Committee, G. F. Sprague, Department of Agronomy.

[2]Dip. Ing., Hochschule f. Bodenultese., Vienna, Austria, 1949. M.S., Iowa State College, Ames, Iowa, 1952. Graduate Assistant, Agricultural Experiment Station.

t-tests. According to the results obtained in the mutant tests the 12 mutants were classified into three groups: 1) mutants where the heterozygous genotype was distinctly superior in all or many of the attributes measured ('sugary 205', 'green stripe', 'dwarf SW1', 'dwarf 187-2' and 'crinkled'); 2)mutants where no heterotic behavior was apparent ('narrow leaf', 'male sterile 317', 'grass like', and 'small seed 1373'); 3) mutants where a classification on the basis of the analyses was intermediate or erratic ('brachytic', 'sugary GG824', and 'small seed M14').

Plants heterozygous for the mutation when selfed or backcrossed to the recessive parent resulted in recovered homozygous recessives. Such recovered recessives were compared with the original recessives to provide some information on the assumption of a single locus difference between parent and mutant line. These recovery tests were grown in 1953. The same attributes were recorded in 1953, as in the mutant tests. Recovery tests for only three mutants were analyzable ('narrow leaf', 'green stripe', and 'dwarf SW1'). Each attribute was first analyzed individually and then three attributes were combined into a discriminant function which was evaluated in an analysis of variance and a t-test. The variance ratio of the discriminant was highly significant in all three recovery tests. This would indicate that the basic assumption of a single gene difference underlying the mutant tests was not correct and that the recovered recessives had undergone some genetic change curing the cross generation.

Two mutants homozygous for the dwarf gene (d_1d_1 and d_2d_2) and their parent lines (D_1D_1 and D_2D_2) unrelated to each other, were intercrossed according to the following scheme: $D_1 \times D_2$, $D_1 \times d_2$, $d_1 \times D_2$, and $d_1 \times d_2$. These four F_1's were grown in a randomized block experiment. Plant height, number of seeds per plant, total kernel weight, kernel row number, and ear length were recorded. In all attributes except number of seeds the difference among the intercrosses were highly significant.

It has been stated that under additive gene action the F_1 hybrid of two inbred lines cannot exceed the sum of the two inbred parents unless overdominance is common. Certain comparisons of the dwarf intercrosses and the dwarf mutant tests, although not evaluable statistically, indicate the inadequacy of this argument as support for overdominance.

A discussion was presented concerning problems involved in heterosis. It is desirable to determine for breeding purposes the relative importance of dominance and overdominance, although this would not provide a critical answer to the basic issue. Cases of overdominance on a single locus, reported in the literature, rarely have involved a homozygous genetic background. The advantage of maize in general and the results obtained in the 12 mutants tested were discussed. The recovery tests are the first extensive data of this nature, their validity and bearing on the mutant tests were evaluated. The data obtained from the dwarf intercrosses bring out the limitations of the argument that inbred A x inbred B > inbred A + inbred B is indicative of overdominance effects.

A SOCIOLOGICAL ANALYSES OF RELEASE PROCEDURES USED IN THE VOCATIONAL PLACEMENT OF INSTITUTIONALIZED MENTAL DEFECTIVES[1]

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For a number of years, institutions for mental defectives in the United States have been placing patients on jobs selected by the institutional staff. Various individual characteristics have been used to select patients for vocational placement. Prior to this study, however, these characteristics had never been validated. The purpose of this study has been, first, to determine if these release characteristics differentiate between successful and unsuccessful placements from the Woodward State Hospital and School, Woodward, Iowa. Second, to use significant release characteristics to predict probability of success for future placements.

[1]Doctoral thesis no. 1498, submitted December 15, 1953. Chairman of Committee, Walter A. Lunden, Department of Economics and Sociology.

[2]B.A., Southern Illinois University, Carbondale, Ill., 1948. M.A., Ibid., 1949. Instructor.

The release characteristics tested have been gathered by a review of the literature, and contacting by letter each institution for mental defectives in the United States, to determine the release characteristics they have been using. These characteristics have been objectified and 56 were available for statistical test purposes.

The data regarding each person in the group studied have been obtained from the personal folder maintained for each patient from the time he enters the institution until he is discharged. Various sections maintained by ward attendants, medical doctors, psychologists, etc., have been utilized.

The group studied had a total of 205 persons. Thirty-nine males and 72 females have been designated as successful placements, while 36 males and 58 females have been classified as unsuccessful. The criterion of success was a complete discharge from the institution, while the criterion of failure was return to the institution from placement through a fault of the patient. Where patients had been returned through no fault of their own, e.g., sickness, inconsiderate employer, etc., they have been eliminated from the group to be studied.

The 56 release characteristics have been tested through the use of chi square or analysis of variance, with correction for disproportionality, depending on the nature of the data.

Twelve of the 56 release characteristics significantly differentiated between successful and unsuccessful placements. Each characteristic related to behavior in the institution. In general, those patients who have adjusted to the institutional routine tend to success on placement. The 12 significant release characteristics were: whether or not a behavior problem; escapee; quarrelsome with employees; quarrelsome with other patients; fights with other patients; truthful; ambitious; obedient; careless; punishment records; steals; and, evaluation of work.

A gross behavior score has been obtained by giving each person in the group studied a plus two for each favorable release characteristic, a plus one for a "fair" or unknown characteristic, and a zero for each characteristic unfavorable to successful placement. The range for behavior scores could be from 0 to 24. The gross behavior scores have been combined and tested by use of analysis of variance, with correction for disproportionality, and they significantly differentiated between successful and unsuccessful placements. The behavior scores were then tested by means of biserial r. It has been found that the tendency to be successful is related to gross behavior score, since the higher the behavior score, the greater the tendency to be successful on placement. Biserial r, however, does not give tendency to be successful for individuals.

The discriminant equation has been used to predict probability of a given individual's chances of success on placement. The formula $V = 0.04029X - 0.54858$, where X equals the individual's gross behavior score, has been used to obtain sigma scores indicating tendency to be successful on placement. The sigma scores have been converted by use of the normal curve into chances in 100 of succeeding on placement. Therefore, the probability of success on vocational placement for patients leaving the Woodward State Hospital and School, Woodward, Iowa, can be predicted through the use of individual gross behavior scores.

RESOURCE PRODUCTIVITY IN AGRICULTURE[1]

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In this study an attempt was made to add to existing knowledge in two ways: (1) through the development and/or refinement of concepts and techniques for the measurement of productivity and (2) through the application of these to data in making empirical estimates of resource productivity and economic efficiency. Four areas were selected to represent different types of agriculture. These were spring wheat in Montana, corn

[1]Doctoral thesis no. 1483, submitted December 11, 1953. Chairman of Committee, Earl O. Heady, Department of Economics and Sociology.

[2]B.S.A., Ontario Agricultural College, Guelph, Ont., Canada, 1949. M.S., University of Massachusetts, Amherst, Mass., 1950. Graduate Assistant, Agricultural Experiment Station.

in northern Iowa and in southern Iowa, and cotton in the Piedmont area of Alabama. In each area samples of farms were selected, and complete input-output data for the year 1950 were recorded by means of surveys of individual farmers. In addition, sample survey data for the two Iowa areas for 1939 were utilized. Two basic techniques of analysis were used. These were: (1) the fitting of various Cobb-Douglas and polynomial production functions to data for each of the areas and (2) the computation of residual "productivities" for groups of farms stratified simultaneously and independently by labor and capital services. In both cases the analysis was made for crop and livestock production treated separately as well as taken together.

The methods employed in the production functions involved three points of departure from preceding studies using similar statistical techniques. These were: (1) the separation of crop production from livestock production, (2) a consistent attempt to measure resource service flows rather than a mixture of flow and stock resources and (3) the elimination of specific items of expense which are not physical inputs.

The production functions as fitted are not pure or ideal. The production function is fitted to observations as they are found in the sample. It provides an estimate of the total product for any and all combinations and quantities of the factors. The predicted product represents that product forthcoming on the average of that kind and from those types of resources and with the specific techniques employed in that vicinity in factor space. The surface is, therefore, a type of hybrid. The productivities which are derived from the functions imply that the techniques of production, type of product etc. must change in the same way between farms as in the sample if the results specified by the production surface (function) are to be obtained in other situations. The fitted surface provides only an average of what existed in the sample, and does not imply that better production methods are not possible.

The Cobb-Douglas function applied to crops or livestock separately may be used to provide an estimate of the general level of productivity in agriculture by geographic areas or type of farming areas and to study the nature of returns to scale. The function may be used also to provide an estimate of the productivity of individual resources in an area, to detect general misallocation of resources and to determine the direction of adjustment required in the long run to improve the level of economic efficiency in an area by resources reallocation. The results of such analysis are probably most useful in comparisons of productivity of individual resources for the area as a whole and for comparisons between areas.

The general level of resource productivity was higher for crops than for livestock. For crops the productivity of resources in the aggregate was highest in Montana followed by north Iowa, south Iowa, and Alabama in that order. For livestock, the differences were much smaller but productivity tended to be highest in Montana, followed by south Iowa, north Iowa, and Alabame in that order. Returns to scale for crops were increasing but were more nearly constant for livestock. The degree of returns to outlay was considerably higher than returns to pure scale. For both crops and livestock in Alabama, a major change in techniques as well as in scale appears to be the only solution to low resource productivity in that area.

The results in both types of analysis indicated that the optimum outlay line is not approximated by any scale line. As output increases in crop production, the optimum outlay line intersects scale lines representing higher ratios of land to other resources and also at higher ratios of machinery to labor. In livestock production, the oprimum outlay line probably intersects scale lines representing higher capital-labor ratios as output increases. Indicated also is the ability to reorganize resources in such a way that large increases in capital may be added without varying labor and without reducing capital productivity materially. Similar increases in labor without changing capital yield very small responses.

ELECTRICAL PROPERTIES OF CRYSTALLINE BORON[1]

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The boron crystals used in this study were prepared by reducing boron tribromide with hydrogen upon contact with a hot (1500°C) tantalum filament. The largest single crystals weighed less than ten micrograms and were a few hundred microns in length. The high purity of the specimens was verified spectrographically and their crystalline nature was verified by means of Laue photographs.

Micromanipulative techniques for mounting very small crystals with several electrical contacts were developed. Microscopic single crystals of boron were mounted with as many as five spring loaded tungsten probes. Measurements were made of voltage current characteristics, resistivity, Hall and thermoelectric effects as functions of temperature. Qualitative studies were made of rectification, forming and photoconductivity.

The voltage current characteristics of crystalline boron were explained in terms of joule heating. The resistivity of crystals typical of the majority of those tested was found to be approximately 1.7×10^6 ohm cm at 25°C. The resistivity of a typical crystal decreased by a factor of almost 10^{10} between the temperatures of 200°K and 1000°K. From resistance data obtained in the temperature range between 700°K and 1000°K the intrinsic energy gap E_g between the filled and conduction bands was computed to be about 1.55 ev.

Hall, thermoelectric, and rectification studies showed the purest specimens of crystalline boron were predominately p-type. It was found that heat treatment could convert typical p-type boron crystals into relatively low resistivity n-type crystals. Hall effect measruements were made on one such heat treated crystal and on another low resistivity n-type crystal selected on the basis of qualitative thermoelectric measurements. From these Hall effect data the mobility of electrons in these particular crystals of boron was calculated to be about 0.7 cm^2/volt sec. From Hall effect data obtained on a typical crystal, the mobility of holes was calculated to exceed that of electrons by about 0.2 cm^2/volt sec. The effective masses of the carriers were calculated to exceed ten electron masses and the mean free paths of the carriers to be between one and one hundred minimum interatomic distances.

[1]Doctoral thesis no. 1458, submitted August 11, 1953. Chairman of Committee, Donald E. Hudson, Department of Physics.

[2]B.A., Cornell College, Mt. Vernon, Iowa, 1930. M.S., Purdue University, Lafayette, Indiana, 1932. Research Assistant, Institute for Atomic Research.

SOIL FACTORS AFFECTING CROP YIELDS ON CLARION-WEBSTER SOILS[1]

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A study was made of the effects of various soil factors on crop production on the Clarion, Webster, and associated soils. The effect of soil differences, which are expressed as soil type differences, as well as differences that have resulted from different soil treatments and rotations, were evaluated in terms of crop yields and soil properties. Rotation experiments which have been in operation since 1915 on the Iowa State College Agronomy Farm at Ames are the principal sources of information.

Continuous corn, corn-oats, corn-oats-meadow, corn-corn-oats-meadow, and corn-corn-oats-meadow-meadow rotations are followed. Various manure and fertilizer treatments are used on each of the different rotations. Clarion loam, Nicollet loam, Webster silty clay loam, Webster silty clay loam (calcareous phase), and Harpster

[1]Doctoral thesis no. 1447, submitted July 17, 1953. Chairman of Committee, Frank F. Riecken, Department of Agronomy.

[2]B.S., University of Missouri, Columbia, Mo., 1935. A.M., Ibid., 1941. Assistant Professor. Cooperator, Agricultural Experiment Station.

silty clay loam are all present in appreciable quantities on the experimental area.

Differences were found to exist in crop yields and in selected soil properties that are correlated or associated with soil type differences. Relative yield differences between soils are different for different crops and for different soil treatments. On the four year, corn-corn-oats-meadow rotation, which is the most suitable rotation for evaluating soil differences, average corn yields on the untreated plots ranged from 52 bushels per acre on the Harpster soils to 70 bushels per acre on the Webster soils. On manured plots, average corn yields ranged from 72 bushels on the Clarion soils, to about 80 bushels per acre on all of the other soils. Thus, the use of manure increased corn yields and reduced the variation in yields between soils.

On comparable soils, the inclusion of a legume meadow crop in the rotation increased average corn yields about 20 bushels and oat yields 25 bushels per acre. Manure applications resulted in yield increases on all crops in all rotations. Corn yield increases, resulting from the use of manure, averaged about 15 bushels per acre.

The use of rock phosphate resulted in moderate increases in yield and in available soil phosphorus on Clarion and Nicollet soils, but gave no increases in calcareous soils. The use of superphosphate resulted in greater yield increases on calcareous soils than on noncalcarious soils.

Available soil potassium was found to be highest on Webster soils and lowest on Clarion soils. Determinations of available soil potassium were not affected by soil treatment, but the percentage of potassium in corn leaves was increased by additions of potassium to the soil.

Total nitrogen and available water were found to be highest for the Webster and lowest for the Clarion soils.

Yields on the experimental area were found to be in general agreement with those obtained by farmers under comparable management systems on similar soils.

A SELECTION INDEX FOR NAVAJO CROSSBRED RANGE LAMBS[1]

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Department of Animal Husbandry

The primary purpose of the study was to construct an index for selecting weanling lambs. Component parts of the index included heritability values of the traits considered, phenotypic and genetic correlations among them, and their relative economic values. The study also yielded information on the desirability of twin lambs.

Data were available on 1078 dam-offspring pairs of Navajo and Nagajo crossbred sheep maintained at the Southwestern Range and Sheep Breeding Laboratory, Fort Wingate, New Mexico.

Six traits were measured when the lambs were approximately 120 days of age. Weaning weight, staple length, medullated fibers and fiber diameter were measured in pounds, centimeters, per cent and microns, respectively. Body type and condition (degree of fatness) were evaluated by scores using a scale ranging from 1 to 5 with merit increasing as score value decreased.

The environmental factors for which the traits were corrected were age of dam, type of birth and rearing, sex and age of lamb. Weaning weight and condition were the two traits most influenced by these factors; staple length was influenced least. Environmental effects upon degree of fiber medullation and fiber diameter were not studied.

Heritabilities of weaning weight, medullation and fiber diameter were found to be 0.21, 0.64, and 0.30, respectively, and are sufficiently high to make mass selection reasonably effective. Heritability values for staple length, body type and condition were 0.06, 0.04, and 0.11 and are low enough that mass selection would be relatively ineffective.

The traits most highly correlated with one another phenotypically were weaning weight and type, weaning weight and condition, body type and condition, and medullation

[1]Doctoral thesis no. 1499, submitted December 18, 1953. Chairman of Committee, L. N. Hazel, Department of Animal Husbandry.

[2]B.S., Utah State College, Logan, Utah, 1940. M.S., Iowa State College, Ames, Iowa, 1948.

and fiber diameter. However, all correlations, except those between staple length and type, staple length and condition, and staple length and weaning weight, were large enough to be statistically significant. The genetic correlations amont the traits were:

	Body type	Condition	Staple length	Medullation	Fiber Diameter
Weaning weight	-0.26	-0.09	-0.10	-0.13	1.19
Type		-2.17	0.68	0.22	0.24
Condition			-2.29	0.24	0.26
Staple length				-0.15	0.36
Medullation					0.45

Three of the above correlations are larger than unity, indicating large sampling errors are associated with these correlations. Some of the correlations are indicative of antagonism between desirable traits in sheep production. Selection for heavier lambs gives shorter staple, and selecting for longer staple or greater fiber diameter results in an increase in medullated fibers.

The difference in pounds of lamb produced by ewes having twins and ewes having singles was 27 pounds for the Navajo ewes and 23 pounds for the crossbred ewes. A significantly higher percentage of single lambs than of twin lambs reach weaning age. Also, a higher death rate was observed in both single and twin crossbred lambs than in Navajo lambs. Heritability of twinning was found to be 0.11 for the mature crossbred ewes and 0.06 for the Navajo ewes.

Relative economic values of the traits were calculated from long time price averages for wool and lambs; relationships between weanling and mature traits were used when these were available. These relative economic values were: Weaning weight, pounds (13.41), body type, score (31.00), condition, score (31.00), staple length, cm. (13.12), medullation, per cent (3.50), fiber diameter, microns (2,00), for each unit change in the trait.

Using information concerning the heritabilities, phenotypic and genetic correlations, and the relative economic values, the selection index was calculated. This index was:

I = 1.00 weaning weight + 7.76 type + 9.10 condition - .84 staple length - 1.11 medullation + 4.96 fiber diameter.

Although the rate of improvement from selection on the basis of this index is slow, as evidenced by the expected genetic gains per generation, the progress which can be expected is more rapid than would be the case if selection were toward ill-defined objectives and carried out in a haphazard manner.

BODY MEASUREMENTS AND BLOOD CONSTITUENTS IN RELATION TO NUTRIENT INTAKE OF IOWA CHILDREN[1]

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Department of Foods and Nutrition

A systematic analysis has been made of certain body measurements and certain blood constituents in relation to each other and to the mean daily intake of nutrients of a state-wide sample of Iowa public school children. One of the main objectives in this study was to observe the dietary intakes and blood constituents of the children who deviated one standard deviation and of those who deviated more than one standard deviation from the mean of the age-sex group in height, weight, and developmental level. A second objective was to note the relationships within the three sub-groups of each age-sex group. To attain these objectives the values of the different nutritional status indices for each age-sex group were divided into three smaller groups according to the mean and standard deviation for each age-sex group.

[1]Doctoral thesis no. 1508, submitted February 22, 1954. Chairman of Committee, Ercel S. Eppright, Department of Foods and Nutrition.

[2]B.S., Pennsylvania State College, State College, Penn., 1941. M.S., Ibid., 1946. Research Associate, Agricultural Experiment Station.

Approximately 1200 children were randomly chosen from 61 representative schools. The schools were randomly selected from the city elementary schools, small town elementary, junior and senior high schools, and the independent and consolidated schools with grades one to twelve. The schools and the children were chosen according to a plan designed by the Iowa State College Statistical Laboratory.

A series of nutritional status measurements was made of the children. A seven-day-dietary record was kept by each child. Also, each child was measured for height and weight. The developmental level was determined by plotting height and weight on the Wetzel Grid. Hemoglobin concentrations were determined for all of the children. The serum ascorbic, serum carotenoid, and serum alkaline phosphatase concentrations were determined for the children who attended the urban and small town schools.

Except for calcium, the boys had mean daily intakes of food energy and nutrients that either exceeded or approached the allowances. Except for calcium and iron, the Iowa girls from 6 to 13 years had mean daily intakes of food energy and nutrients that either approached or exceeded the allowances. From 13 to 18 years the girls had intakes of protein, thiamine, and riboflavin, in addition to calcium and iron, that were below the allowances; otherwise, the values fluctuated about the allowances.

The tallest, heaviest and rapidly developing boys and girls from 6 to 13 years tended to have higher intakes of the various nutrients than the shortest, lightest and slowly developing boys and girls at corresponding ages. At different ages the shortest, lightest and slowly developing boys and girls had intakes of the various nutrients that failed to meet the allowances more frequently than did the other groups of children. The teenage girls of greatest physical development, whether based on height, weight or developmental level, had diets which frequently failed to meee tht allowances in nutritive value.

Serum ascorbic acid and serum carotenoid concentrations reflected not only the dietary intake, but also the rate at which the children were growing. The boys and girls who were the tallest, heaviest and developing rapidly exhibited a marked decrease in the serum ascorbic acid and carotenoid concentrations with age until a minimal concentration was reached at 15 years for the boys, and 13 to 15 years for the girls. The decrease with age was less marked for the other groups of boys and girls.

With the average children the year-to-year changes in mean serum alkaline phosphatase concentrations followed similar trends whether the classification was based on height, weight or developmental level. In the extreme groups year-to-year changes of the concentration of serum alkaline phosphatase tended to be more alike where classified according to height and developmental level than to weight. The children with the highest serum alkaline phosphatase reached the maximum mean value a year later than the children with average values. The children with the lowest values had no peak concentration, the levels remained about the same throughout the age range.

Hemoglobin concentrations of the boys were highly correlated with the mean daily intakes of protein, niacin, riboflavin, and iron. A multiple regression showed age to be the most influential factor predicting the hemoglobin concentration. The addition of the other independent variables protein, niacin, riboflavin, and iron improved the estimate only slightly.

The method of analyzing data used in the present investigation was exploratory. The results from these analyses suggest the need of further study of nutritional status of children who are maturing at different rates.

LOW TEMPERATURE HEAT CAPACITIES OF THORIUM, GADOLINIUM, AND ERBIUM[1]

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A description of the construction and operation of an adiabatic calorimeter for use in the temperature range 15-300°K has been presented. The methods used in the treatment of data and calculation or results have been discussed.

The heat capacity of thorium was measured from 15-300°K. The thermodynamic functions were calculated for the range 0-300°K, where the heat capacity between 0-15°K was obtained using a Debye extrapolation with $\theta_D = 141.6$. The value obtained for $S^\circ_{219.16}$ was 12.760 e.u., where e.u. represents cal. deg.$^{-1}$ (g. atom)$^{-1}$. No anomalies occur in the heat capacity of thorium over the temperature range of this experiment.

The heat capacity of gadolinium was measured from 15-355°K. The thermodynamic functions were calculated for the range 0-355°K, where the heat capacity between 0-15°K was obtained using a Debye extrapolation with $\theta_D = 152$. The value of $S^\circ_{298.16} = 15.744$ e.u. was obtained. An enhanced heat capacity associated with the ferromagnetic behavior has been observed, with a maximum at 18.6°C. This compares with the Curie temperature of 16°C found for gadolinium by magnetic measurements (1).

A separation of the various factors contributing to the heat capacity has been made where $C_p = C_q + C_m + C_e + \delta C$. In this equation C_p is the total heat capacity at constant pressure, and C_q, C_m, C_e, and δC are the lattice, magnetic, electronic, and dilatation contributions to the heat capacity. The entropies associated with each term have been assumed to be separable in a similar fashion.

At 360°K the entropies associated with the lattice, electronic, and dilatation contributions to the heat capacity of gadolinium were found to be 13.698 e.u. Subtracting this from the total measured entropy at 360°K of 17.238 e.u. gives a magnetic contribution of 3.540 e.u. This compares favorably with the predicted magnetic entropy of R ln 8 or 4.132 e.u., considering that some magnetic entropy still remains above 360°K.

Values of the heat capacity associated with the energy of magnetization were calculated according to the Weiss theory of ferromegnetism and were found to be 2.5, 3.1, and 5.4 cal. deg.$^{-1}$ (g.atom)$^{-1}$ at 8, 10, and 14°C. These correspond to measured values of 5.60, 5.85, and 6.45 cal. deg.$^{-1}$ (g.atom)$^{-1}$ at the same temperatures. The experimental value of the heat capacity discontinuity was found to be in disagreement with predictions of the Weiss theory, and statistical theories of ferromagnetism did not appear applicable in the case of gadolinium.

The heat capacity of erbium was measured from 15-320°K. The thermodynamic functions were calculated for the range 0-320°K, where the values of heat capacity from 0-15°K were obtained from a Debye extrapolation with $\theta_D = 89$. This value of θ_D was obviously too low for the lattice contribution only, but was thought to account for anomalous contributions of magnetic origin in this temperature range. A value of $S^\circ_{298.16} = 17.593$ e.u. was obtained.

Three maxima are found in the heat capacity of erbium; at 19.9°K $\pm$ 0.3°, at 53.5°K $\pm$ 0.3°, and at 84°K $\pm$ 0.5°. The two maxima at the lower temperatures were found to be dependent upon the thermal history of the sample previous to measurements, and this dependence was investigated. The maximum at 84°K corresponds in temperature to anomalous behavior in the resistivity (2), magnetic susceptibility (3), and the neutron diffraction (4). The behavior of these properties would seem to predict a Néel point around 84°K, but the neutron diffraction cannot be interpreted by any simple antiferromagnetic model. There is no correspondence of anomalous behavior in the properties of erbium with the 53.5°K maximum, except the onset of field dependence in the magnetic susceptibility, which would not be expected to contribute to the heat capacity. The possibility of transitions similar to those found for cerium, praseodymium, and neodymium (5) is suggested. The maximum at 19.9°K corresponds to the temperature at which erbium has been predicted, by means of magnetic susceptibility measurements (3), to become ferromagnetic. Neutron diffraction studies indicate that erbium is definitely ferromagnetic at 4.2°K, but they do not predict the exact temperature at which ferromagnetism sets in.

[1]Doctoral thesis no. 1566, submitted June 8, 1954. Chairman of Committee, Maurice Griffel, Department of Chemistry.

[2]B.S., University of Nebraska, Lincoln, Nebr., 1949. Research Assistant, Institute for Atomic Research.

Table 1

Predicted and experimental values of S°_{300} for the rare earth metals

Element	O_D	$S_q + S_e$ [c] e.u.	J [a]	R ln (2J+1)	Pre.	Exp. S_p
La	132	13.41	0	0	13.41	13.64 [b]
Ce	135	13.29	5/2	3.56	16.85	16.68 [b]
Pr	138	13.16	4	4.37	17.53	17.49 [b]
Nd	141	13.04	9/2	4.57	17.61	17.54 [b]
Pm	144	12.92	4	4.37	17.29	- -
Sm	147	12.80	5/2	3.56	16.36	- -
Eu	- -	- -	7/2	4.13	- -	- -
Gd	152	12.57	7/2	4.13	16.70	15.83
Tb	155	12.44	6	5.10	17.54	- -
Dy	159	12.32	15/2	5.51	17.83	- -
Ho	162	12.20	8	5.63	17.83	- -
Er	165	12.08	15/2	5.51	17.59	17.63
Tm	168	11.95	6	5.10	17.05	- -
Yb	- -	- -	0	0	- -	- -
Lu	174	11.71	0	0	11.71	- -

[a] The total angular momentum quantum number of the tripositive ion, except for europium and ytterbium where J is for the dipositive ion.

[b] These experimental values of S_p were obtained from reference 5.

[c] The lattice and electronic contributions to the heat capacity at 300°K.

The various contributions to the heat capacity and entropy were separated as in the case of gadolinium. The lattice, electronic, and dilatation contributions to the entropy at 300°K were found to total 12,208 e.u. Subtracting this from the total measured entropy at 300°K gives a magnetic entropy of 5.426 e.u. In the metal, the erbium atoms have been assumed to possess the same electron core as in the tripositive ion, with the valence electrons engaged in the bonding bands of the metal. The spectroscopic state of the free tripositive ion is $4I_{15/2}$. At 0°K all of the ions should be in the lowest of the 2J + 1 or 16 possible energy states, and as the metal is warmed, the atoms will assume a random distribution in the 16 states. The entropy involved in this process is R ln 16 or 5.382 e.u. This predicted value of the magnetic entropy is in close agreement with the value derived from the heat capacity data.

The Debye characteristic temperature, θ_D, was found to increase in going from lanthanum to gadolinium, indicating that the force constants, or binding forces, increase as the atomic number increases and are the dominating factor in determining θ_D.

The entropies at 300°K for all of the rare earth metals have been estimated, and the values are shown in Table 1. These values are based on the following assumptions: that the lattice heat capacity varies linearly as the series is traversed, and is determined by the values of θ_D = 132 for lanthanum and θ_D = 152 for gadolinium; that the

electronic heat capacity is the same for all rare earth metals, and equal to that of lanthanum (5); that the dilatation correction for all the rare earth metals is negligible; and that the magnetic entropy is that predicted for the free tripositive ion. Europium, ytterbium, and possibly samarium are not expected to agree with these predictions because of their tendency to exhibit extraordinary valences.

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ADAPTATION OF CENTRAL AMERICAN PLANTS TO IOWA[1]

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Four species of plants, Euchlaena mexicana, Solanum muricatum, Physalis ixocarpa, and Lathyrus tingitanus, were grown in the greenhouse at photoperiods of 12, 14, 15, and 16 hours; and at low (55° to 65°F), medium (70° to 80°F), and high (85° to 100°F) temperatures for the purpose of evaluating the possibility of their adaptation to Iowa. The photoperiod experiment was conducted at the medium temperature, and day-length for the temperature experiment was that which prevailed from January to April.

Vegetative response of E. mexicana to the four photoperiods was uniform, but only those plants subjected to 12 hours of light per day developed reproductive organs. Conversely, vegetative development was strikingly affected by temperature. The mean heights of plants grown at low, medium, and high temperatures were 7.0, 29.3, and 71.2 inches, respectively. Only the plants at high temperature had flowered at the end of 159 days.

Vegetative and reproductive responses of S. muricatum to the four photoperiods were not significantly different. Mean heights of plants grown at low, medium and high temperatures were 13.5, 26.0, and 33.3 inches, respectively. The number of days to flower-bud formation at the respective temperatures was 94, 57, and 50. Attempts to induce fruit setting with chemical growth regulants, anther extracts, root pruning, leaf pruning, girdling, and mulching were unsuccessful.

The four photoperiods had not apparent effect on either the vegetative or reproductive responses of P. ixocarpa. Mean heights of plants grown at low, medium, and high temperatures were 9.3, 15.6, and 23.6 inches, respectively; and the number of days to flowering was 112, 76, and 61, respectively.

Mean total lengths of L. tingitanus plants at 12, 14, 15, and 16 hours were 319.5, 96.7, 79.4, and 50.4 inches, respectively. Those at a 12 hour photoperiod did not flower; the others were uniform in date of flowering. Mean total lengths of plants grown at low, medium, and high temperatures were 46.2, 143.8, and 83.1 inches, respectively. Plants at low temperature flowered in 88 days, those at medium temperature in 76 days, and those at high temperature did not flower.

Photoperiods are long and temperatures high during much of the growing season in Iowa. These factors are favorable for the vegetative development of E. mexicana, however, according to these data it is a short day plant, and, therefore, not adaptable to Iowa in its present form, as a grain crop. S. muricatum appears to be unaffected by photoperiods and temperatures such as encountered in Iowa during the growing

[1]Doctoral thesis no. 1476, submitted December 8, 1954. Chairman of Committee, W. F. Buchholtz, Department of Botany and Plant Pathology.

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season; however, until the factors that prevent fruit setting can be ascertained and corrected, this plant can not be considered adaptable. All the data obtained in these experiments indicate that P. ixocarpa in its present form could well be grown in Iowa. The reaction of L. tingitanus to photoperiod indicates its adaptability to northern latitudes, but very poor growth at high temperature excludes Iowa as an area of adaptation.

The Mayan husk tomato was grown and observed at Ames in 1952 and 1953. Selections were made for further study.

Plants grown at 70°F were more desirable for use as transplants than those grown at either 60° or 80°F.

In an experiment involving direct seeding and transplanting on May 16, 31, and June 15, transplanting on May 16 and 31 resulted in greater yields than any other combination of date and method.

Disease and insect pests observed in 1953 were, powdery mildew, virus disease, Fusarium species, Heliothis armigera, H. virescens subflexa, Trichobaris trinotata, and Gnorimoschema lavernella.

In preliminary experiments with the virus disease, seeds taken from badly diseased plants produced seedlings free of symptoms. In a field study, 42 per cent of the plants sprayed weekly with DDT exhibited virus disease symptoms as compared to 72 per cent of the unsprayed plants.

Tip killing of branches and vascular discoloration of tap roots and stems were prevalent in the field experiments in 1953. Young plants grown in steamed soil infested with Fusarium isolates taken from typical field specimens also exhibited tip necrosis and vascular discoloration.

Heliothis armigera and H. virescens subflexa damaged fruits by feeding. Over a five-week period an average of 42.5 per cent of the fruit was damaged by these insects.

Trichobaris trinotata larvae were found feeding inside the tap roots and stems. Infestation was most severe on the transplants of May 16 and 31 and on directly seeded plants of May 16.

Gnorimoschema lavernella infestation was light but the damage was serious. The larva of this insect enters the fruit and, through feeding, produces a cavity just beneath the point of stem attachment. This cavity is loosely filled with web and the pupa is suspended in this web.

Chemical analyses revealed no strikingly great amounts of nitrogen, calcium, magnesium, or ascorbic acid in the fruits. Total sugar percentages were approximately equal for fully ripe and half ripe fruits and for nearly ripe fruits stored for one week at 8°, 20°, and 25°C.

TYPES OF FUNCTIONS[1]

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In this dissertation X denotes the real continum E_1 or an interval, open or closed, contained in E_1. The function f(x) is a function from the set X to a subset of E_1. N denotes an arbitrary open interval in E_1, and N(x) an arbitrary open interval containing the point x.

Real functions of a real variable may be classified according to whether or not they are continuous, neighborly, cliquish, or discriminative. These properties are defined as follows:

Definition 1. The function f(x) is said to be continuous at the point ξ in X if for every positive number ε, there exists an $N(\xi)$ such that for every x in $N(\xi)\cdot X$, $|f(x)-f(\xi)| < \varepsilon$.

Definition 2. The function f(x) is said to be neighborly at the point ξ in X if for every positive number ε and for every $N(\xi)$, there exists an N contained in $N(\xi)\cdot X$ such that for every x in N, $|f(x)-f(\xi)| < \varepsilon$. (1)

[1]Doctoral thesis no. 1531, submitted May 26, 1954. Chairman of Committee, H. P. Thielman, Department of Mathematics.

[2]B.A., Reed College, Portland, Ore., 1943. M.A., Oregon State College, Corvallis, Ore. 1949. Instructor.

Definition 3. The function f(x) is said to be cliquish at the point ξ in X if for every positive number ε and for every $N(\xi)$, there exists an N contained in $N(\xi)\cdot X$ such that for every two points x_1 and x_2 in N, $|f(x_1)-f(x_2)| < \varepsilon$. (2)

Definition 4. The function f(x) is said to be discriminative at the point ξ in X if for every positive number ε and for every $N(\xi)$, there exist an η in $E[y: |y-f(\xi)| < \varepsilon]$ and an N contained in $N(\xi)\cdot X$ such that for every x in N, $f(x) \neq \eta$.

The function f(x) is said to be continuous if f(x) is continuous at each point of X. Similar definitions hold for neighborly, cliquish, and discriminative functions.

In addition to these properties the following concepts appear in this dissertation.

Definition 5. The function f(x) is said to be uniformly neighborly on X if for every two positive numbers ε and δ and for every x in X, there exist a positive number δ_1, independent of x, and an interval N_{δ_1}, contained in $N_\delta(x)\cdot X$ such that for every x_1 in N_{δ_1}, $|f(x)-f(x_1)| < \varepsilon$.

Definition 6. The function f(x) is said to have the Darboux property on X if for every two points x_1 and x_2, $x_1 < x_2$, in X such that $f(x_1) < f(x_2)$ ($f(x_1) > f(x_2)$), and for every η such that $f(x_1) < \eta < f(x_2)$ ($f(x_1) > \eta > f(x_2)$), there exists an x such that $x_1 < x < x_2$ and such that $f(x) = \eta$.

Definition 7. The function f(x) is said to be peculiar with respect to the property p on X if X may be partitioned into two sets X_1 and X_2 such that X_1 and X_2 are each everywhere dense in X, f(x) has the property p at each point of X_1, and f(x) has the property p at no point of X_2. (2)

The object of this dissertation is to investigate functions having the properties defined above, and to discover how these properties are related. The principal results are the following:

Theorem 1. If the function f(x) is increasing or decreasing at each point of an everywhere dense set in X, then f(x) is cliquish on X.

Theorem 2. If f(x) is neighborly and bounded on the finite interval I, open or closed, then f(x) is uniformly neighborly on I.

Theorem 3. If a bounded function f(x) is discriminative and possesses the Darboux property on X, then f(x) is cliquish on X.

Theorem 4. If the function f(x), defined on the open interval I, is of Baire's class less than two and has the Darboux property, then f(x) is neighborly on I.

Theorem 5. If the function f(x), defined on X, is of Baire's class less than two, and has the Darboux property, then f(x) is neighborly on both sides on X. Conversely, if f(x) is of Baire's class less than two, and is neighborly on both sides on X, then f(x) has the Darboux property on X.

Theorem 6. If a function f(x) has a derivative f'(x) at each point of X, then f'(x) is neighborly on X.

Theorem 7. If the function f(x) has a derivative f'(x) everywhere on X with the possible exception of a nowhere dense set in X, then f'(x) is cliquish on X.

Theorem 8. If a point property p is such that for every function f(x) defined on X the set of points where f(x) has the property p is closed, then there is no function peculiar with respect to the property p.

Theorem 9. There exists no function f(x) peculiar with respect to the property of having the saltus function $s_f(x)$ satisfy the inequality, $s_f(x) \geq k > 0$, at a point.

In addition to these results, numerous examples are given in order to extend and clarify the theory.

Probably the most important result obtained in this dissertation is Theorem 6. For functions which have a derivative at every point, the knowledge that the derivative function is neighborly gives added insight into the nature of the possible discontinuities of the derivative function.

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ISOLATION AND DETERMINATION OF NUTRITIONAL FACTORS IN FOOD AND FODDER YEAST[1]

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An investigation was conducted to find a way of producing dry, bland protein concentrates from yeast. This investigation was based on the precept that protein molecules are so large that they are relatively odorless and tasteless. The taste in yeast was assumed to be due to the low molecular weight substances associated with the protein. The problem, therefore, involved a search for methods of breaking the yeast cell wall and removing the taste-producing substances from the protein.

The literature review included: (a) a review of the different methods for rupturing yeast cells; (b) an investigation of the literature on proteins regarding the factors of safety, quality, quantity and unit cost; and (c) a survey of the chemical constituents in yeast.

It was desired to determine whether yeast cells could be exploded in such a manner as to release all of the cell protein under conditions suitable for producing protein concentrates. The exploding technique followed was to heat a yeast slurry in a closed system to a temperature greater than the boiling point of the intracellular fluids at atmospheric pressure. The external pressure on the yeast cells was then rapidly released to the atmosphere by opening a quick-opening valve or by releasing the slurry through an orifice. In theory, this would allow the external pressure to be released more rapidly than the internal cell pressure could diffuse through the cell wall. If the cell temperature was high enough, the pressure differential created should rupture the cell wall.

Three exploding devices were constructed to test this theory. One was a batch type, quick-opening autoclave. The other two used a heat exchanger continuously to heat the yeast slurry and then released the yeast through an orifice to the atmosphere. One heat exchanger was directly heated by a battery of Bunsen burners. With it a yeast slurry could be heated to 120°C in 5 to 15 seconds. The other continuous heat exchanger was steam heated, and a heating time of 0.5 to 3 minutes was required to heat the yeast.

Releasing a slurry of bakers' yeast from the batch autoclave at 0, 20, 40, 60, 80, 100, 120, 140, and 160 psi steam pressure resulted in the liberation of 0, 13.5, 14.7, 14.1, 22.3, 29.5, 29.5, 36.0, and 42.8 per cent, respectively, of the total nitrogen from the cells. This was determined by removing the cell debris by centrifugation, washing with physiological saline, combining the centrifugates and determining the soluble, cell free nitrogen by Kjeldahl analysis. It was possible to release 79.9 per cent of the total nitrogen by increasing the total heating time at 160 psi from 12.75 minutes to 17 minutes.

By using the continuous heat exchangers, it was possible to release from 16.5 to 60.5 per cent of the total cell nitrogen by increasing the temperature of release from 100° to 160°C. However, the amount of protein nitrogen released, as determined by alcohol precipitation and Kjeldahl analysis, was between 3.76 and 9.83 per cent of the total when the heating time was between 0.64 and 15 minutes.

By inserting a condenser between the steam heat exchanger and the orifice, it was possible to prove that between 100° and 160°C all of the yeast nitrogen was released by the heating effect rather than the exploding effect. Moreover, above 160°C, the product tended to scorch. On the basis of these results it was concluded that removal of all the yeast protein by exploding would be impractical for protein concentrate production.

However, it was possible to extract the taste from yeast slurries heated to 120° for less than 3 minutes. Ethanol was found to be better than water, vegetable oil, or fat solvents for removing the taste from yeast protein. For example, a torula yeast slurry containing 13.5 per cent solids was heated 1.31 minutes at 126°C. The solids were recovered by centrifugation and extracted with 95 per cent ethanol. The product, when air dried, was creamy-white, very bland and contained 59 per cent protein. This represented a recovery of 76.5 per cent of the total nitrogen.

[1]Doctoral thesis no. 1528, submitted May 17, 1954. Chairman of Committee, L. A. Underkofler, Department of Chemistry.

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One of the by-products from the production of bland yeast protein concentrates is a water-alcohol soluble factor(s) which promotes cellulose digestion by rumen organisms.

a. It is found in torula and bakers' yeast and in Bacto yeast extract.
b. It is soluble in water and in mixtures of water and alcohol. It is slightly soluble in 95 per cent ethanol.
c. Ashing destroys it.
d. The factor(s) could be dialyzed.
e. It could not be adsorbed on Nalcite HCR cation exchange resin or Amberlite IRA-410 anion exchange resin.
f. It was not possible to steam distill the factor(s) at pH 1 or pH 6.
g. It was not soluble in ether.
h. It was possible to adsorb the factor(s) on Norite A at pH 5 and elute it at pH 7.

Several colorless, transparent isolation agar media were devised using 1 per cent of CMC-70L as the only carbohydrate source. CMC-70L is a sodium salt of carboxymethylcellulose containing 0.65 to 0.85 carboxymethyl substitutions per glucose residue. These media, being transparent, made it easy to isolate, observe and transfer colonies of cellulolytic organisms.

Several rumen organisms were isolated. Organism No. 32, a motile, strictly anaerobic, Gram variable, rod-shaped bacterium was used as an assay organism. It fermented and produced acid from cellulose, CMC-70L, starch, dextrin, maltose, glucose, and cellobiose.

In order to maintain anaerobic conditions in the inoculum, the cultures were grown in rubber-capped, 15-ml. centrifuge tubes. The cultures could be washed without removing them from the tube. The inoculum suspension was transferred dropwise by inserting a device similar to a wash bottle into the centrifuge tube. Pressure was supplied by a rubber bulb. Carbon dioxide was used to flush the oxygen from the system.

The results of this investigation indicate that it should be possible to use transparent CMC-70L broth media for acid titration or turbidimetric assay of factors required by cellulose-digesting organisms.

THE URANIUM-CARBON SYSTEM; THE STRUCTURE OF DIMETHYLBERYLLIUM AND ITS BEARING ON CHEMICAL VALENCE[1]

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Department of Chemistry

The Uranium-Carbon System

A constitutional diagram of the Uranium-Carbon system has been constructed from metallographic, thermal, chemical, and X-ray data. Two compounds, UC (4.8 wt% carbon) and UC_2 (9.16 wt% carbon), have been identified. There is no evidence of solubility of uranium or of higher carbides in UC. UC is stable at room temperature. UC_2 is stable only at high temperature and partially decomposes into UC and C at lower temperatures. At high temperatures and at compositions in the vicinity of 7 wt% C there is a possibility that either a compound, U_2C_3, which dissolves UC and UC_2, exists or that UC and UC_2 form a continuous solid solution which extends over a range of approximately 9 atomic per cent. Although the Widmanstatten type structure indicates that the postulated U_2C_3 exists as one phase at high temperature, all attempts to retain this one phase structure by quenching have been unsuccessful. Results of other workers indicate that at a composition corresponding to U_2C_3 a compound with very narrow solubility limits and unstable at temperatures above 1600°C can be produced in samples that have been cold or hot worked. It has been shown that this compound, stable only below 1600°C, is not the phase which has decomposed into two phases to give the Widmanstatten structure.

The solubility of carbon in liquid uranium up to 1800°C is small (less than 0.60 wt%),

[1]Doctoral thesis no. 1079, submitted July 12, 1950. Chairman of Committee, R.E. Rundle, Department of Chemistry.

[2]Sc. B., Brown University, Providence, Rhode Island, 1943. Research Assistant, Institute for Atomic Research.

but the solubility increases rapidly with temperature thereafter. The gamma-beta and beta-alpha uranium solid transformations are not affected by the presence of carbon.

UC has a face centered cubic structure (NaCl type) with $a_o = 4.948 \pm 0.001$. UC_2 has a tetragonal structure (CaC_2 type) with $a_o = 4.947 \pm 0.001$ and $c_o = 5.987 \pm 0.001$A.

The Structure of Dimethylberyllium

The proposal that metals with more low energy orbitals than valence electrons should form electron-deficient compounds when combined with groups with no unshared pairs has suggested that electron-deficient binding might occur in dimethylberyllium, a solid subliming at about 200°C.

Dimethylberyllium is orthorhombic with the following lattice constants: $a_o = 6.14$; $b_o = 11.53$; $c_o = 4.18$ A. It contains four $Be(CH_3)_2$ units per unit cell. Weissenberg and precession data indicate the space groups D_{2h}^{26}-Ibam or C_{2v}^{21}-Iba.

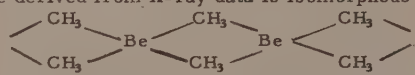
Atomic positions were determined by trial and error methods and checked by Patterson and Fourier projections. The hydrogen atoms contribute significantly to the intensities of low order reflections. In space group C_{2v}^{21}-Iba the atoms are at the following positions.

4 Be at OOz; O, O, $\frac{1}{2}$ + z plus (OOO; $\frac{1}{2}\frac{1}{2}\frac{1}{2}$)

8 C at $\overline{xy}$O; $\overline{xy}$O; x, $\overline{y}$, $\frac{1}{2}$; $\overline{x}$, y, $\frac{1}{2}$ plus (OOO; $\frac{1}{2}\frac{1}{2}\frac{1}{2}$)

with $x = 0.182 \pm 0.002$; $y = 0.101 \pm 0.002$; $z = 0.25 \pm 0.03$. In space group D_{2h}^{26}-Ibam the x and y parameters have the same values as those given above and the z parameter is equal to 1/4.

The structure derived from X-ray data is isomorphous with that of SiS_2. Continuous chains



with approximately tetrahedral configurations about beryllium are found in agreement with the fibrous nature of the crystals. The bond pair, Be-C-Be contains one electron pair. The observed Be-C distance is 1.93 ± 0.02 A for the centrosymmetric space group. The C-Be-C angle in the ring is $114 \pm 1°$. Methyl-methyl distances between chains are 4.1 A which is normal for Van der Waals bonding, so that negative methyl ions are not indicated.

Space group C_{2v}^{21}-21 would permit two short and two long bonds to beryllium, but intensity data restrict the difference to 0.1 A, too symmetrical to allow structures similar to Pitzer and Gutowsky's proposal for trimethylaluminum. It is suggested that the bonding in the trimethylaluminum dimer is similar to that in dimethylberyllium.

This is the first established electron-deficient bonding in the second group, the second outside the third group, and the second in which the methyl group is found bound to more than one other atom.

Metallic Valences

Two different sets of valences are now being applied to metals in alloys, that of Hume-Rothery, Mott and Jones, and Pauling. In the former, metallic valences approach a minimum of or nearly zero for the transition metals, whereas in the latter a maximum of about 5.78 is reached for the same metals.

The applicability of both ot these valence ideas to explanations of alloy solubility limits stoichiometric composition of intermetallic compounds, and the theory of metallic bonding has been discussed. In many of these applications the principle which has been used is that electron-to-atom ratio is an important factor in intermetallic interactions. It has been shown that for very many applications the Pauling valences lead to exactly the same correlations and conclusions as do the Hume-Rothery, Mott and Jones valences.

A method of determining which valence set is the more applicable to explain intermetallic bonding has been proposed. Assuming constancy of electron-to-atom ratio is the governing factor in determining the isothermal solid solubility boundaries in ternary solutions, one may predict the slopes of the ternary solubility boundary curves if the valences of all of the components are known. By choosing ternary systems for which two of the components have valences for which Hume-Rothery and Pauling give identical values, one may find the valence the third element by comparing various predicted solubility boundary curves with the experimentally determined ones. Precautions which must be followed in this procedure and some possible ternary systems which fulfill the necessary conditions have been discussed.

CAUSTIC TREATMENT OF ZIRCON IN THE PREPARATION OF PURE ZIRCONIUM COMPOUNDS[1]

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This investigation was conducted in order to develop a process whereby the most abundant zirconium ore, namely zircon, could economically be put into solution and purified adequately for use in hafnium separation processes employing liquid-liquid extraction. Secondary aims concerned the preparation of pure zirconyl chloride, zirconyl nitrate, zirconyl sulfate, and zirconium oxide from the zircon ore.

Caustic soda was found to be a suitable agent for the decomposition of zircon sand (zirconium silicate). Using an optimum ratio of 1.1 parts by weight of caustic soda to one part of zircon sand, sodium zirconate and sodium silicate with small amounts of sodium silicozirconate were formed after heating for one to two hours in a furnace set at an optimum temperature of about 650°C. The resulting product was a light-colored, granular material from which the water-soluble sodium silicate was easily removed in a hot water leaching operation. The water-insoluble zirconates were put into solution with hydrochloric acid. Zirconyl chloride was then crystallized from this solution to remove iron, titanium, some silica and other soluble impurities. The crystalline zirconyl chloride was then separated from its mother liquor in such a manner as to give a very dry crystal. These crystals were then put into a water solution which was clarified in order to remove silica. The resulting zirconyl chloride solution could be used directly to make feed material for the liquid-liquid extraction systems, or processes further to give high purity zirconium (or zirconyl) compounds such as oxide, chloride, nitrate, and sulfate.

The total cost per pound of zirconium processed by this method was estimated to be about 50 cents. This figure compares favorably with the present cost of about 90 cents per pound of zirconium content commercially available as zirconium tetrachloride. The product of the caustic treatment was also of a higher purity than that from the tetrachloride.

[1]Doctoral thesis no. 1249, submitted March 5, 1952. Chairman of Committee, Harley A. Wilhelm, Department of Chemical Engineering.

[2]B.S., University of Michigan, Lansing, Mich., 1945. M.S., University of Rochester, Rochester, N.Y., 1949. Graduate Assistant, Institute for Atomic Research.

A COMPATIBLE RECORDING-TABULATION TECHNIQUE APPLIED TO A STATISTICAL STUDY OF ATMOSPHERIC TEMPERATURE FLUCTUATIONS[1]

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Department of Physics

This investigation was concerned with the development of a compatible recording-tabulation technique and the application of this technique to a preliminary statistical study of the turbulent temperature fluctuations in the first eight meters of the free atmosphere. This investigation was made with the support of the Base Directorate for Geophysical Research, Air Force Cambridge Research Laboratories, under Contract No. AF19(122)-440.

The instrumentation aspects of this investigation involved: (1) the development of a recording system which permitted the recording of the very low frequency electrical, analog signals derived from several thermistors used as temperature sensing elements and (2) the development of a play-back system which reconstructed the originally recorded electrical signals and (3) the development of an automatic tabulating device which accepted the signals and tabulated their amplitude fluctuations in such a manner

[1]Doctoral thesis no. 1562, submitted June 7, 1954. Chairman of Committee, Percy H. Carr, Department of Physics.

[2]B.S., Iowa State College, Ames, Iowa, 1945. Research Associate, Industrial Science Research Institute.

as to permit the very efficient calculation of such statistical measures as their means, standard deviations and correlation coefficient.

The basic element of the recording and play-back systems was a standard broadcast-quality single-track magnetic tape recorder. An electronic sampling modulator was constructed which permitted the sequential recording of seven separate variables. The individual variables were sampled two-hundred times a second with a sample duration of 180 micro-seconds. The modulator permitted a recording frequency-band-width from DC to several tens of cycles per second. The play-back demodulator separated and reconstructed the originally recorded signals for use with the tabulator. The prime function of the recording and play-back systems was to provide a memory for the tabulator so that the raw data were preserved and were available for more than one type of analysis.

The function of the tabulator was to accept directly an electrical signal whose magnitude at any instant was proportional to the variable of interest, sample the signal periodically and count the number of samples during the test that the signal was in any one of ten pre-set amplitude class-intervals. The tabulator thus exactly duplicated the operation which a person would perform manually in the analysis of a varying quantity. The tabulator was also capable of accepting two signals, determining by sampling in which of ten pre-set class-intervals each signal existed and tabulating the results on a one-hundred cell correlation array by counting the number of samples in each of the one-hundred possible combinations of the two variables that occurred.

An analysis was also undertaken to determine the effects of system noise upon the various statistical measures which were used. The results were presented in an analytical form.

The experimental aspects of this investigation involved a study of the dependence of the intensity of thermal fluctuations and the vertical scale of thermal turbulence upon atmospheric stability. The intensity was characterized by the standard deviation of the temperature fluctuations from their mean value, and the vertical scale of thermal turbulence was inferred from the correlation coefficient derived from the temperature fluctuations at two elevations above the ground. Stability was expressed as the parameter β, which is the exponent in the wind profile equation developed by Deacon (1949).

The data used in this investigation were obtained during the Great Plains Turbulence Field Program at O'Neill, Nebraska, during August and September of 1953. (The field test was sponsored by the Base Directorate for Geophysical Research, Air Force Cambridge Research Laboratories.) The temperature data were obtained from a vertical array of six Western Electric bead thermistors type D-176980, spaced 25, 50, 100, 200, 400, and 800 centimeters above the ground. The wind data for the computation of the β were obtained from a vertical array of three experimentally developed very light and responsive cup-type anemometers. The anemometers were spaced 100, 400, and 700 centimeters above the ground. Recordings of temperature fluctuations and average wind velocity were made under a variety of conditions of stability. The values of β range from 0.60 to 1.08.

The experimental results of this investigation indicate that there is a relationship between atmospheric stability and the intensity of thermal fluctuations. The standard deviation of the fluctuations is larger during periods of instability than during periods of stability and further there appears to be very little overlap of the range of values for the two cases. A tendency was also found for the standard deviation of the temperature fluctuations to increase with height during periods of stability and to decrease during periods of instability. The standard deviations found ranged from 0.10°C to 1.60°C.

The results of the study of the scale of thermal turbulence, as inferred from the correlation coefficient between adjacent levels, indicate a decrease in the scale of turbulence as stability increases and further, the mean vertical scale of turbulence was in no case found to increase as rapidly with height as did the thermistor spacings.

The results of this investigation were compared to the results of similar investigations and an area of disagreement noted. The disagreement is in the sense of the dependence of the standard deviations of the temperature fluctuations upon atmospheric stability, and the sense of the dependence of the correlation coefficient upon atmospheric stability. In both cases the results of this investigation indicate an increase in the quantity with a decrease in stability. It is felt that a major cause for the disagreement lies in the entirely different frequency responses of the instruments used. The instruments used in this investigation were capable of responding to much higher frequencies than those of the other investigators. The lag-time of the thermistors as used in this investigation was of the order of 0.1 second.

PURIFICATION AND CHARACTERIZATION OF FUNGAL CARBOHYDRASES[1]

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Department of Chemistry

The use of fungal enzyme preparations for the saccharification of starchy materials produces larger quantities of fermentable sugars than does the use of malt preparations. However, the yield of ethyl alcohol is quite variable when the fungal preparations are used regardless of strict control over the physical conditions. As a part of an effort to isolate the fungal enzymes responsible for the hydrolysis of starch, the purification of the limit dextrinase and maltase of Aspergillus niger NRRL330 was undertaken. The carbohydrase system of A. niger NRRL330 was selected for study because previous work had shown that the filtrate of a submerged culture of this organism contained high concentrations of the three major carbohydrases, alpha-amylase, maltase, and limit dextrinase. In addition, a considerable amount of information concerning the metabolism of this organism is available in the literature. The purification of the maltase and limit dextrinase of this organism was undertaken as a part of an effort to determine their specific roles in the hydrolysis of starch.

The purification procedure developed by Underkofler and Roy (1) for the purification of limit dextrinase from submerged culture filtrates of A. oryzae failed to give comparable results with the A. niger strain. The first steps involving ammonium sulfate precipitations were suitable for concentration of the enzyme and elimination of much of the maltase activity as well as nonproteinaceous material. However, the following steps resulted in excessive loss of enzyme activity, and an alternative procedure would be desirable.

The protein material possessing limit dextrinase activity is distinct from that possessing at least the bulk of the maltase activity. Different proportions of the two enzyme activities were eliminated in the various steps in the procedure. The protein fraction possessing the limit dextrinase activity may possess limited maltase activity.

The lengthiness of the analytical procedure developed by Back, Stark, and Scalf (2) severely delimited the possibilities for research. Several possible alternative methods were investigated. A partially purified solution of limit dextrinase displayed a limited tendency to hydrolyze bacterial dextran. The extent of the hydrolysis was so slight that this method was impractical as an analytical procedure. Panose, a trisaccharide composed of three glucose residues connected by an alpha-1, 3- and an alpha-1,4-glucosidic linkage, was hydrolyzed by this partially purified solution, but due to the presence of the alpha-1,4-glycosidic linkage the results were difficult to interpret. The rapid and virtually complete hydrolysis of isomaltose suggested the possibility of developing this procedure into a method of analysis for the enzyme capable of hydrolyzing the alpha-1,6-glucosidic linkages in short chain molecules.

A procedure was developed for the purification of maltase. Preliminary ammonium sulfate precipitations conducted in various buffers indicated that there were probably at least two protein fractions possessing maltase activity. The isoelectric point of one fraction was near pH 5.0 and the other was pH 7.0. The fraction having the lower isoelectric point contained the largest portion of enzymic activity and was the one isolated. The maltase activity was stable between pH 4.0 and 7.0 for at least 96 hours with a maximum loss of 7.5 per cent.

Alpha-amylase was precipitated at a much lower concentration of ammonium sulfate than was maltase. At 65 per cent ammonium sulfate concentration approximately 60 per cent of the alpha-amylase activity was precipitated while only 19 per cent of the maltase activity was precipitated. This may have been due to a lower molecular weight on the part of the maltase.

Acetone was capable of precipitating the enzyme from crude or only partially purified filtrates, but had no effect upon the solutions from which most of the protein material had been removed. The precipitation of the active material from the crude solution may have been due to adsorption of the active protein upon some inert impurity.

This hypothesis was strengthened by the discovery that the enzyme molecule could be adsorbed by a large, inert molecule such as starch from a 40 per cent aqueous-

[1]Doctoral thesis no. 1507, submitted February 8, 1954. Chairman of Committee, L. A. Underkofler, Department of Chemistry.

[2]B.S., Purdue University, Lafayette, Indiana, 1948. M.S., Iowa State College, Ames, Iowa, 1951. Graduate Assistant, Industrial Science Research Institute.

acetone solution at 0°C. The extent of adsorption was influenced by the size of the starch particle, the smaller particles being, in general, the more efficient adsorbents. Soluble starch was found to remove most of the alpha-amylase activity while not affecting the maltase. Maltase is reversibly adsorbed upon potato starch under these conditions. A possible method of procedure for separating alpha-amylase and maltase would be, first, to use soluble starch to remove most of the alpha-amylase activity and, then, to use potato starch (with subsequent elution) to remove the maltase activity from the solution and to concentrate the active material.

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2. Back, T.M., W.H. Stark, and R.E. Scalf. Measurement of enzymatic activity of limit dextrinase. Anal. Chem. 20:56-60. 1948.

ESTROGENIC SUBSTANCES IN CERTAIN LIVESTOCK FEEDS AND THEIR INFLUENCE UPON THE NUTRITION OF GROWING AND FATTENING LAMBS[1]

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In view of the use of the synthetic estrogen, diethylstilbestrol, to stimulate increased weight gains in cattle and sheep and improved carcass finish in poultry, the possible widespread occurrence of natural estrogenic substances in livestock feeds posed the problem that they may have considerable significance not previously recognized in the nutrition of livestock. The purpose of this study was to determine the distribution of estrogenic substances in livestock feeds and study their influence upon the nutrition of growing and fattening lambs.

Estrogenic activity was detected in alfalfa hay, clover hay, and soybean oil meal. The estrogenic activity was detected and assayed by noting the increase in uterine weight of immature female mice receiving injections of the various plant extracts, and comparing this uterine response to that noted in similar mice receiving injections of standard doses of diethylstilbestrol. The estrogenic potency of clover and alfalfa hay was estimated to be equivalent to 2 and 2.7 micrograms, respectively, of diethylstilbestrol activity per pound of hay tested. It was found that approximately two-thirds of the estrogenic potency was lost during the final steps of purification of the clover hay extracts, therefore the estrogenic potency of the clover hay tested was considered to be a minimum value. It was noted that the estrogenic potency in both clover and alfalfa hay increased with the advance in the growing season. One pound of soybean oil meal was found to contain approximately 9 micrograms of stilbestrol activity. Also, estrogenic activity was detected in one sample of moldy yellow corn. This corn was obtained from a farmer who reported a high incidence of prolapse of the rectum in pigs being fed the corn.

Crystalline genistin and genistein isolated and prepared from soybean oil meal as well as the synthetic isoflavone derivatives, biochanin A, formononetin and daidzein, all exhibited estrogenic properties as measured by the mouse uterine response technique. The last three compounds are also found in soybean oil meal and certain other livestock feeds.

Four lamb feeding experiments were conducted in order to determine the influence of feeding clover hay extract or crystalline genistin extracted from soybean oil meal upon gain in weight and carcass quality of lambs.

Lambs fed a crude extract of clover hay in which the estrogenic fraction was concentrated made faster liveweight gains than similar control animals, however the

[1]Doctoral thesis no. 1536, submitted May 28, 1954. Chairman of Committee, Wise Burroughs, Department of Animal Husbandry.

[2]B.S., West Texas State College, Canyon, Texas, 1938. B.S., New Mexico College of Agricultural and Mechanic Arts, State College, N.M., 1939. M.S., Iowa State College, Ames, Iowa, 1950. Graduate Assistant, Agricultural Experiment Station. Instructor.

number of experimental animals was limited and the difference was not statistically significant. The carcasses from lambs fed a crude hay extract were superior in grade and contained more fat than was present in carcasses from control animals.

The addition of crystalline genistin or low levels of diethylstilbestrol to the lamb rations stimulated increased weight gains, feed consumption, and improved carcass finish of fattening lambs during the winter and spring months. In two summer feeding experiments, however, the addition of these estrogenic substances failed to have beneficial effects similar to those noted in the winter and spring experiments. It was postulated that the responses of lambs to supplemental feeding of genistin of low levels of diethylstilbestrol may be related to season involving the sexual behavior and endogenous estrogen level in sheep. No harmful effects were noted in lambs fed genistin or low levels of diethylstilbestrol.

RESPONSES OF YEAST TO 2,4-D[1]

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Numerous investigations have been conducted on the effects of 2,4-dichlorophenoxyacetic acid (2,4-D) on the metabolism of higher plants. Although much has been learned of the effects of 2,4-D on the chemical composition, enzyme activity, and growth responses of treated plants, the work is complicated by differential penetration and translocation effects, as well as cellular and tissue interaction. The cellular approach was adopted for the present investigations in order to study the effect of 2,4-D on plant metabolism, independent of the interactions involved in multicellular organisms. Bakers' yeast (Saccharomyces cerevisiae) was selected as the test organism because this single-celled plant is readily accessible and a large amount of work has been done in establishing its normal metabolism.

Growth studies were carried out in liquid nutrient medium, and growth was measured as the percentage transmission of light by the turbid yeast suspensions. Yeast growth was not stimulated by 2,4-D but slight inhibition was produced over a wide range of concentrations. Marked inhibition of growth was obtained with concentrations exceeding 10^{-3} M at pH 6.0, and complete inhibition of growth occurred at 2×10^{-2} M. Recovery of treated cultures after removal of the 2,4-D was complete within 44 hours with a 20-hour prior treatment up to 4.5×10^{-2} M, above which growth was not resumed. Up to the critical concentration of 4.5×10^{-2} M there was apparently a direct relationship between growth and degree of saturation of the growth sites with 2,4-D. A loose bonding between the 2,4-D molecule and its substrate is postulated, because growth was resumed readily when the chemical was removed before the critical time-concentration effect was reached. Above the critical time-concentration, the complete cessation of growth seems to be best explained by postulating a destruction or alteration of the normal protoplasmic structure.

Although growth and respiration were both affected by 2,4-D, the growth response was more sensitive. Respiration was stimulated only slightly at a concentration which severely inhibited growth. Studies on the effect of 2,4-dinitrophenol (DNP) on metabolism have shown that growth may be inhibited at concentrations which have no effect on respiration. It has been postulated that DNP acts through uncoupling phosphorylation from oxidation, thus increasing respiration in tissues in which the phosphorylating system limits the respiratory rate. The data on the relationship between growth and respiration of yeast treated with 2,4-D suggest the operation of a mechanism similar to that of DNP.

Aerobic, endogenous O_2 uptake and CO_2 evolution were stimulated over a narrow range of concentrations. High RQ values resulted at inhibitory concentrations because CO_2 evolution was depressed less than O_2 uptake. Below the critical concentration for growth there was no alteration in RQ, indicating that there was no change in the type of

[1]Doctoral thesis no. 1464, submitted November 30, 1953. Chairman of Committee, W. E. Loomis, Department of Botany and Plant Pathology.

[2]B.S., North Dakota Agricultural College, State College, N.D., 1948. M.S., Ibid., 1949. Graduate Assistant, Agricultural Experiment Station.

substrate oxidized. Anaerobic, endogenous CO_2 evolution was markedly stimulated by 2,4-D, indicating an induction of endogenous fermentation. Anaerobic, exogenous CO_2 evolution was not affected except at the highest concentration of 2,4-D used. Aerobic, exogenous O_2 uptake was progressively inhibited with increasing concentration of 2,4-D, but the inhibitory effect was maintained only at concentrations of glucose at or above the optimum for yeast respiration. At the highest concentration of 2,4-D used, aerobic and anaerobic, exogenous respiration, as well as aerobic endogenous respiration, were strongly inhibited, indicating a general disruption of metabolic functions.

The depression of glucose uptake in yeast treated with 2,4-D was approximately equivalent to the calculated innibition of glucose oxidation in treated yeast respiring exogenously in air. Dissimilation of reserve carbohydrates was accelerated by 2,4-D, even in the presence of exogenous glucose. The increased polysaccharide dissimilation in the absence of exogenous carbohydrate was approximately equivalent to the calculated stimulation of glucose oxidation in yeast respiring endogenously.

It is postulated that 2,4-D probably acts through the stimulation of fermentation of reserve polysaccharides, with a simultaneous inhibition of the oxidative, synthetic processes involved in growth, possibly through an uncoupling of phosphorylation from oxidation. Stimulated endogenous respiration may be attributed to the accelerating effect of 2,4-D on the dissimilation of reserve carbohydrates, resulting in an increase in respirable substrate. The reduction of exogenous respiration by 2,4-D may be due to an interference with glucose absorption, or may indicate a direct interference with respiratory processes which is not evident when the substrate is limiting in endogenous respiration.

It was shown that the total concentration of 2,4-D required to produce a standard response (maximum stimulation or 50 per cent inhibition of respiration) decreased greatly as the pH of the medium was lowered. On the basis of undissociated 2,4-D, however, a narrow range of concentrations was required to produce a standard response over the pH range employed, indicating that penetration is limited largely to the undissociated 2,4-D molecule. The activity of 2,4-D may be dependent upon the internal pH of the cell and the concentration of 2,4-D ions within the cell.

The respiratory response of yeast to several 2,4-D compounds showed that the monoisopropanol amine salt and the sodium salt of 2,4-D were equally stimulatory. The n-butyl ester was initially less stimulatory and finally more stimulatory than the salts. The greater range of concentrations over which the ester was stimulatory may be attributed to a greater penetration of the undissociated ester, but a slower production of ions within the cell.

ECOLOGY OF THE VIRGINIA AND KING RAILS AND THE SORA IN CLAY COUNTY, IOWA[1]

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The ecology of the Virginia rail, Rallus limicola limicola Vieillot, the king rail, R. elegans elegans Audubon, and the sora, Porzana carolina (Linnaeus), game birds of the subfamily Rallinae, was investigated on prairie kettlehole marshes on Dewey's Pasture Public Shooting Ground, Clay County, Iowa during the spring and summer of 1951 and 1952 and early spring of 1953. Field observations, including inspection of nests, trapping and banding were the methods of study. The major objectives were: (1) to determine the species and relative abundance of rails in Clay County, (2) to determine the factors limiting their abundance and (3) to learn something of their local and migratory movements.

Seventy-eight occupied nests, including 37 of Virginia rails, six of king rails, and 35 of soras, and 46 unoccupied rail nests were observed. Although 145 Virginia rails, four king rails, and 130 soras were trapped and banded or marked, none was reported

[1]Doctoral thesis no. 1444, submitted July 17, 1953. Chairman of Committee, George O. Hendrickson, Department of Zoology and Entomology.

[2]B.S., University of Minnesota, Minneapolis, Minn., 1941. M.S., Pennsylvania State College, State College, Penn., 1948.

from any locality other than the research area. All recoveries were of birds that had been banded in the same year that they were recaptured.

In 1951, the first Virginia rails and soras appeared April 30, the first king rails May 2. In 1952, Virginia rails first were noted Aptil 29, and in 1953, April 30. The spring migration of the other rail species was not observed in 1952 or 1953. Virginia rails last were trapped October 3, 1952, and soras September 27, 1952, although traps were operated until October 23 that year. September 2, 1951 was the latest data that king rails were captured.

The 1951 nesting season extended from May 13 to July 12 for the Virginia rail, from May 13 to June 23 for the king rail, and from May 13 to June 26 for the sora. The 1952 nesting season extended from May 15 to July 1 for the Virginia rail and began May 7 for the sora. No king rail nests were found during 1952.

The minimum distances in feet between occupied nests were 56 between Virginia rail nests, 50 between sora nests, 352 between king rail nests, 56 between Virginia rail and sora nests, 102 between sora and king rail nests and 264 between Virginia rail and king rail nests.

In 1951, the range, mean and standard deviation of the water-depth in inches at occupied nests of each rail species were, respectively: Virginia rail (27 nests), 6.0-18.0, 12.1 $\pm$3.2; king rail (six nests), 4.0-18.0, 10.6 $\pm$5.5; and sora (26 nests), 5.0-20.0, 12.8 $\pm$3.4. In 1953, the water-depths in inches were: Virginia rail (eight nests), 11.5-22.0, 14.8 $\pm$3.2; and sora (six nests), 13.0-23.0, 18.9 $\pm$3.7.

Virginia rail nests were found in six cover-types: lake sedge, Carex lacustris (64.9 per cent); round-stemmed bulrush, Scirpus acutus and S. heterochaetus (10.8 per cent); river bulrush, Scirpus fluviatilis (10.8 per cent); cat-tail, Typha latifolia and T. angustifolia (8.1 per cent); river grass, Scolochloa festucacea (2.6 per cent); and blue-joint grass, Calamagrostis canadensis (2.7 per cent). King rail nests were found in two cover-types: lake sedge (66.7 per cent) and river bulrush (33.3 per cent). Sora nests were found in five cover-types: lake sedge (71.4 per cent); river bulrush (11.4 per cent); round-stemmed bulrush (8.6 per cent); bur-reed, Sparganium eurycarpum (5.7 per cent); and cat-tail (2.9 per cent).

In 1951, the range, mean and standard deviation of the clutch-size (number of eggs per complete clutch) for each rail species, were, respectively: Virginia rail (23 clutches), 4-10, 8.1 $\pm$1.8; king rail (four clutches), 8-14, 12.0 $\pm$2.7; and sora (18 clutches), 5-12, 10.2 $\pm$1.8. In 1952, the clutch-size statistics were: Virginia rail (five clutches), 7-10, 8.2 $\pm$1.2; and sora (six clutches), 9-11, 9.5 $\pm$0.8.

The incubation period for the Virginia rail was 22 days in one nest, 19 in another and at least 18 in two others; for the king rail at least 20 days in one nest and at least 21 in another; and for the sora 19 days in each of four nests and 20 in another.

In 1951, hatching occurred in Virginia rail nests June 6 to July 12 with a peak in the latter half of June, in king rail nests June 9-23, and in sora nests June 1-26, with a peak june 11-20.

Of 27 Virginia rail nests observed in 1951, 77.8 per cent were successful. Of 190 eggs in the 27 nests, 75.7 per cent hatched, 6.8 per cent were destroyed by small birds, 5.3 per cent by raccoons, 5.3 per cent by flood, and 4.7 per cent by hail, while 1.1 per cent were infertile and 1.1 per cent disappeared from clutches that otherwise remained unharmed. Of six king rail nests observed in 1951, 66.7 per cent were successful. Of 60 eggs in the six nests, 65.0 per cent hatched, 21.7 per cent were destroyed by an unidentified mammal, probably raccoon or mink, 10.0 per cent were deserted, 1.7 per cent were infertile and 1.7 per cent disappeared from a clutch which otherwise remained unharmed. Of 26 sora nests observed in 1951, 57.7 per cent were successful. Of 228 eggs in the 26 nests, 55.3 per cent hatched, 21.9 per cent were destroyed by small birds, 7.0 per cent by raccoons, 6.6 per cent by flood and 4.4 per cent by an unidentified mammal, while 3.1 per cent were deserted and 1.8 per cent were infertile.

In 1951, the nesting densities in 81.4 acres of cover on 28 kettleholes inspected for nests were as follows: Virginia rail, a nest per 3.0 acres; king rail, a nest per 13.6 acres; and sora, a nest per 3.1 acres. In 1952, the nesting densities in 26.5 acres of cover on 10 kettleholes inspected for nests were as follows: Virginia rail, a nest per 2.6 acres; sora, a nest per 2.9 acres. The highest nesting densities recorded on individual kettleholes were a nest per 0.3 acre for the Virginia rail and the sora, and a nest per 1.3 acre for the king rail. The Virginia rail and the sora each nested in isolated kettleholes as small as 0.3 acre.

By August 1, 1951, and July 2, 1952, a few young Virginia rails were on the wing,

whereas a few young soras were able to fly as early as July 20, 1951, and July 3, 1952. In each year trapping records indicated that all of the young Virginia rails were able to fly by September 1 and all of the young soras by the last week of July.

Flightless adult Virginia rails undergoing the postnuptial molt were observed July 27, August 13, and August 29, 1951, and July 15, and July 30, 1952. An adult sora which had nearly completed the postnuptial molt was observed September 1, 1951. Juvenile Virginia rails and soras began the postjuvenal molt in July; by September many of them appeared nearly adult.

The range, mean and standard deviation of the weights of adult rails in grams were, respectively: Virginia rail (43 birds), 67.6-116.2, 88.6 $\pm$ 11.0; king rail (six birds), 284.4-401.5, 322.6 $\pm$ 44.8; and sora (18 birds), 66.9-101.5, 81.1 $\pm$ 11.6.

RESPONSES OF FARMERS TO DIFFERENCES IN CROP YIELD VARIABILITY IN TWO COUNTIES IN NORTH DAKOTA[1]

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The focus of this study was on the variability and uncertainty of farm income in North Dakota. The specific problem investigated was limited to that significant part of income variability which is caused by annual variations in crop yields and to that part of the impact of this variability which constitutes the danger of bankruptcy. On the grounds that insufficient recognition has been given to the part played in farmers' value systems by the goal of security and their preference for certainty, part of the problem was to explore farmers' motivations in the actions they take to adjust to the risk of insolvency.

Four sets of hypotheses were developed to explore the relationships between yield variability, other vulnerability factors, crop insurance participation, and other security practices. Each set consisted of a major hypothesis and a number of subsidiary hypotheses that were theoretical extensions of the major one. Vulnerability factors were farm characteristics, in addition to yield variability, that are largely outside the limits of the average farmer's control, but which tend to threaten his security or solvency. Security practices were various practices which farmers employ to gain security.

The method was to draw conclusions regarding farmers' motives and objectives by observing their behavior responses to various stimuli. To isolate the risk factor two counties in North Dakota, Burke and Eddy, were selected that had virtually the same long-time county average wheat yields (9.9 and 9.8 bushels per acre, respectively) but widely divergent coefficients of variation of those wheat yields (73 per cent and 49 per cent, respectively). This unusual condition was presumably due to variation around a lower mean rainfall but a heavier type of soil in Burke County than in Eddy County. Further, Eddy County had a higher water table, in effect tending to put both a floor and a ceiling on yields in that county. The sample was stratified on the basis of federal crop insurance participation in the year of the survey—those who had crop insurance and those who had not. In the schedule an attempt was made to avoid hypothetical questions, but rather to relate actual behavior to real stimuli.

In testing hypotheses and judging significance of comparative differences, weight was given both to probability levels of the tests of the individual subhypotheses according to the standard "t" test as applied to the differences, and to consistency of direction that was displayed by a set of subhypotheses as a group. That is, the direction of the differences was stated in each subhypothesis. Hence, it was assumed that the greater the proportion of the subhypotheses that showed evidence consistently in the directions stated, the greater the confidence in the major hypothesis.

The first two major hypotheses were comparative statements relating to differences in motives and behavior between the two counties divided on the basis of yield variability. The first major hypothesis stated that high-risk-area farmers, on the average,

[1]Doctoral thesis no. 1484, submitted December 11, 1953. Chairman of Committee, Earl O. Heady, Department of Economics and Sociology.

[2]B.S.A., University of Saskatchewan, Canada, 1942. M.Sc., Ibid., 1944. Instructor. Cooperator, Agricultural Experiment Station.

are more vulnerable than low-risk-area farmers with respect to 12 vulnerability measures which constituted the subhypotheses. Without exception, these 12 factors were found to pose a greater threat to farmers' security in high-risk Burke County than in low-risk Eddy County. In summary, the farmers in Burke County had smaller equities, both absolutely and as a proportion of their total assets. They were obliged by practical circumstances to have a larger proportion of their total assets in the form of real estate and machinery, and a smaller proportion in livestock. Natural conditions favored a relatively straight cash-crop economy in Burke County with very little scope for diversification.

Having identified the conditions and stimuli, the second major hypothesis stated that high-risk-area farmers practice more security measures than low-risk-area farmers, with respect to 25 items which constituted the subhypotheses. These security practices were various security-achieving techniques which the more vulnerable farmer should practice more intensively if he places a premium on security. According to the data, the behavior responses occurred in the manner predicted with few exceptions. In summary, Burke County farmers, as compared with Eddy County farmers, refrained from using as much borrowed capital, kept more reserves both liquid and physical, maintained more flexibility in their farm organization, practiced certain yield-stabilizing cultural techniques more estensively, such as summerfallow, and were more inclined to favor various income-guaranteeing insurance schemes.

The third and fourth major hypotheses were comparative statements related to differences in motives and behavior on the basis of stimuli other than county average yield variability. The third major hypothesis stated that more high-vulnerability farmers subscribe to federal crop insurance than those with low vulnerability, using the same vulnerability factors as before. The relationships in this case were weaker than formerly, because yield variability was held equal, but most of the measures were consistent with the major hypothesis. Hence the conclusion was that, given the same county average conditions of yield variability, farmers who are in a more vulnerable position will tend to take crop insurance in greater numbers than those who are less vulnerable.

The fourth major hypothesis stated that farmers with crop insurance, which presumably gives them a measure of security, tend to employ fewer additional security devices. The subhypotheses related to the same items as the second major set. The relationships indicated were not strong, but it was concluded that crop insurance participation tends to be high where debts are high and where reserves, both physical and monetary, are low. The suggestion also was that the various cultural practices are employed along with crop insurance.

It was concluded that farmers are sensitive to the conditions of extreme yield variability and hold a strong preference for security, especially when it is threatened. In these circumstances, they will make adjustments in order to preserve their solvency even at the expense of a certain degree of long-run income possibilities. However, they will not employ a particular security technique regardless of its cost but will attempt to substitute alternative means or employ several together. With explicit recognition of the co-existence of the goal of security with the goal of income, a more useful research program should be possible.

RELATIONSHIP BETWEEN SIZE OF SCHOOL, EXPENDITURE, AND QUALITY OF EDUCATION IN ELEMENTARY SCHOOLS[1]

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In the United States, the increase in pupil attendance, the increased demand for more and better educational services, and the declining value of the dollar have resulted in the great increase in educational expenditures. Many local school districts whose main source of revenue is the property tax, can no longer finance an adequate program

[1]Doctoral thesis no. 1513, submitted March 11, 1954. Chairman of Committee, M. L. Cushman, Department of Vocational Education.

[2]B.A., Punjab University, India, 1940. B.T., Ibid., 1943. M.S., Iowa State College, Ames, Iowa, 1952.

of education without assistance from other sources. Demands have been made upon the states to contribute a larger proportion of educational expenditures. The states, in turn, have insisted on more efficient use of school funds through more adequately organized school districts. The study of relationships between size, cost, and quality of education, therefore, seems very important.

The purpose of this study was to determine the relationship between size of school, cost of education, and quality of education in the elementary schools of Iowa.

A review of previous studies on the size-cost-quality relationship revealed that, as size of school increased, the quality of education generally improved; the increase in size was accompanied by decrease in cost per pupil; and the increased expenditures produced improved quality. But most of the studies dealt with the school systems either larger or more expensive than the average schools in Iowa. Two studies which included all the public schools of the state, attempted to determine the complex interrelationships between size of school, cost per pupil, and number of course offerings in secondary schools only. The present study attempts to determine these relationships in the elementary schools of Iowa.

Due to lack of evidence of cost of a good program in smaller schools and the weight of opinions of experts that an elementary school of less than 175 to 210 pupils could not provide an adequate program without excessive expenditures, the study was limited to the school districts which maintained 12 grades of instruction and which had an enrollment of 200 or more in the elementary school but nor more than one elementary attendance unit in 1952-53. Copies of A Time-Scale and The Growing Edge along with score sheets were sent to a 50 per cent sample of 255 such schools. One hundred schools responded. The community school scores were obtained from the responses to two previous studies and the pupil achievement scores were obtained from the Director, Basic Skills Testing Program, State University of Iowa, Iowa City.

In order to get a more comprehensive measure, four different measures of quality; i.e., a time-scale score, the growing edge score, the community school score, and the pupil achievement score were used. Coefficients of correlation were computed between all the possible pairs of these measures. All the correlations except two were nonsignificant. It indicated that they measured different aspects of quality independently of one another. The scores of these four measures of quality were combined into single standard scores (mean = 100 and standard deviation = 30) in two ways, (a) by weighting them equally in terms of their standard deviations and (b) by weighting tham by regression of size, discarding the growing edge score, whose correlation with size was negative but not significant. The coefficient of correlation of .848 between the standard scores of quality as thus determined indicated that the two scores of quality were not significantly different from each other.

A highly significant negative correlation between cost per pupil and average daily attendance indicated that inverse relationship existed between the two, i.e., the larger the school, the lower the cost per pupil.

Six different curves were tried to see which one best fitted the data. The evidence found indicated that the relationship between the average daily attendance and cost per pupil was curvilinear. The quadratic and the reciprocal curves had the highest correlations, of .342 and .327, respectively, but the former showed a tendency for an increased cost per pupil beyond average daily attendance of 353 pupils, which, from a logical consideration, was indefensible if quality of the program was held constant. The reciprocal curve showed that the cost per pupil decreased as the size of school increased but tended to level off at approximately $190 per pupil. The smaller schools were spending 23 per cent more money per pupil than the larger schools included in this study.

The highly significant correlation between the standard scores of quality and W-scores $[W = 10,000,000/(\text{average daily attendance})^2]$ indicating that as the size of the school increased, the quality also improved. The single variable regression showed that the quality score of a school of 180 pupils was 77 while that of a school of 480, was 121.

Sufficient evidence was not found to support the statement that relationship existed between the quality and cost per pupil.

Regression equations were developed to predict equally-weighted and regression-weighted standard scores of quality from the cost per pupil and the average daily attendance. Caution must be used in applying these equations for prediction of quality of education by extrapolation to schools smaller or larger than the 255 herein studied. Tables of equally-weighted and regression-weighted scores of quality were constructed

for the ranges of size of school and cost per pupil included in the study. The table of equally-weighted scores of quality showed that the smaller schools had lower scores of quality. A school of 200 pupils spending $200 per pupil had a quality score of only 84. It could increase its score to 100 by spending $375 per pupil or increasing its size to 240 and spending $225 per pupil.

The contribution of the size of school and cost per pupil in production of quality of education in elementary schools of Iowa within the noted size range was found to be in the ratio of 49:1.

The general conclusion of the study is that size of school is much more important than the cost per pupil in the determination of quality of education, as herein defined, in the elementary schools of Iowa having 200 or more pupils and not more than one attendance unit.

THE DEVELOPMENT OF A QUANTITATIVE HYDROGENATION METHOD: THE USE OF THIS AND OTHER METHODS IN FOLLOWING THE PROGRESS OF OXIDATION IN MILK FAT[1]

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One of the common defects in milk and its products is the occurrence of oxidized flavor. The flavor generally is considered to be the result of the oxidation of one or more components of the lipid fraction of the product. A review of the literature reveals that there is no general agreement as to the mechanism of the production of this flavor. Although a considerable number of methods have been used in studying oxidizing fat, none seems to give the desired correlation with flavor deterioration.

The objectives of this study were (a) to develop a quantitative hydrogenation procedure for fats, (b) to determine whether or not the oxygen uptake during the useful life of a fat could be measured from the iodine and hydrogenation iodine values, (c) to compare changes in hydrogenation iodine value with changes in peroxide development, tocopherol degradation, carbonyl formation, and organoleptic evaluation of milk fat (in attempts to determine accurately the extent of previous oxidation and to predict the rate of subsequent oxidation) and (d) to study the effects of season of production and of storage temperature on the results obtained by the methods listed in (c). It was also hoped that this study would give a greater insight into the mechanism of fat oxidation during the period in which the fat is edible.

Hydrogenation was chosen as a method of analysis to be developed for a study of oxidizing fats because the hydrogenation value might be expected to increase upon oxidation of the fat while the iodine value would likely remain constant as long as the fat was edible. A review of the literature failed to reveal any hydrogenation method which was considered to be sensitive enough for the study desired.

The basic equipment used in the hydrogenation procedure was the Barcroft-Warburg apparatus. Several modifications were found necessary; the chief of these was the elimination of all flexible tubing by providing an all-glass system. Mercury was used as a manometer fluid; a layer of propionic acid above the mercury was necessary to prevent fouling of the manometer by lubricants which migrated from the ground joints. Platinum oxide catalyst was prepared on an inert carrier by a modification of the method of Voorhees and Adams (2). It was necessary to clean glassware in a nitric-sulfuric acid bath, and to soak it in dilute NH_4OH for eight hours after the acid cleaning to render it satisfactory for the hydrogenation procedure.

Values closely approximating theoretical were obtained by hydrogenating methyl oleate, methyl linoleate, and methyl linolenate. The iodine values obtained by Breazeale's modification (1) of the Rosenmund-Kuhnhenn method were approximately eight to ten per cent below the theoretical values for the polyunsaturated esters. The reason for this is not known; it apparently is not a function of reaction time.

[1]Doctoral thesis no. 1457, submitted August 10, 1953. Chairman of Committee, Emerson W. Bird, Department of Dairy Industry.

[2]B.S., University of Missouri, Columbia, Mo., 1946. M.A., Ibid., 1948. Graduate Assistant, Agricultural Experiment Station.

The hydrogenation method as adopted gave good agreement among replicate values obtained on fats direct from -25°C storage. For a March fat with a hydrogenation iodine value averaging 33.25 (eight determinations) the values varied by a maximum of 0.09 unit (standard deviation of 0.028 unit). A June fat with an average value of 40.68 varied by a maximum of 0.23 unit; the standard deviation was 0.083 unit. The hydrogenation value was always higher than the iodine value; the differences were not alike for the two fats. The difference between the two methods averaged 0.39 and 1.37 units for the March and June fats, respectively. Unless a greater portion of the polyunsaturated compounds failed to react here than with the methyl esters, there apparently is not enough linoleate and linolenate in milk fat to account for the differences encountered.

In the study of oxidizing milk fat, the hydrogenation iodine value and the peroxide and carbonyl contents generally tended to increase while the iodine value and the numerical flavor score decreased. At the lower temperatures (-25° and 4°C) tocopherol appeared to increase but decreased at the higher temperatures (25° and 40°C). The reason for this apparent increase at the lower temperatures has not been determined but may result from the formation of reducing compounds. These compounds may be aldehydes although the rapid production of carbonyl compounds at higher temperatures and the accompanying decrease in tocopherol would tend to indicate otherwise.

Although only two fats were studied, flavor scores indicate that the June fat deteriorated more rapidly than the March fat. However, a greater rate of change in each of the chemical analyses occurred in the March fat than in the June fat. This would seem to indicate either that the compounds responsible for oxidized flavor are not carbonyl compounds or that not all carbonyl compounds are produced at the same rate.

The degrees of unsaturation of the two fats would suggest a greater susceptibility toward oxidation for the June fat. In contrast to this, the lesser tocopherol as a natural antioxidant in the March fat might be expected to permit more rapid oxidation of the March fat than of the June fat. In contrast to general experience with milk and cream in the dairy industry, the June fat oxidized more rapidly than did the March fat (as determined by flavor).

Increases in temperature accelerated the rates of change of the analytical values. However, the thermal coefficients were not uniform for the various reactions nor between fats for the same reaction. This suggests that the courses of the oxidations are not the same for the higher temperatures as for the lower ones. Therefore, reactions accelerated by increase in temperature alone would not be expected to show exactly what will happen at the lower temperatures normally used for the storage of dairy products.

The lack of significant correlations between the results of the chemical analyses and the organoleptic observations seems to indicate that none of the chemical methods employed in this study is reliable either as a measure of the degree of oxidation having already occurred or as a tool (used alone) in predicting the useful shelf life of a fat.

Two alternative hypotheses concerning the relationships among peroxide content, tocopherol content and flavor scores were presented. In both hypotheses, it was considered that free radicals produced in the oxidation process may take part in three types of reactions, namely (a) reactions producing peroxides, (b) chain termination reactions related to tocopherol oxidation and (c) reactions producing compounds responsible for oxidized flavor. In one hypothesis, the flavor reaction is considered chain propagating while in the other it is chain terminating. It is felt that the relative rates of these three types of reactions may differ from one fat to another and may be responsible for such observed occurrences as a greater tocopherol degradation during the formation of a given amount of peroxide in the June fat than in the March fat and a greater rate of tocopherol degradation in the March than in the June fat.

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2. Voorhees, V., and R. Adams. The use of the oxides of platinum for the catalytic reduction of organic compounds. I. J. Am. Chem. Soc. 44:1397-1405. 1922.

RESPIRATORY AND ENZYMATIC ACTIVITY IN CORN SEEDS IN RELATION TO VIABILITY[1]

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The objective of this investigation was to determine the extent to which respiratory metabolism measured after 18 hours soaking was correlated with ability of corn seeds to grow. Manometric measurements of overall respiratory activity and colorimetric measurements of the activities of malic and alcohol dehydrogenase and cytochrome oxidase were made on corn embryos from 31 lots of varying viability. The indices of growth measured on each lot were germination tests, cold tests (measures of ability of seeds to germinate under adverse conditions) and vigor ratings (based on velocity of germination). Because of the metabolic nature of tetrazolium reduction, tetrazolium tests and tetrazolium ratings (estimates of the amount of tetrazolium reduced) were also made on each lot for comparison with the indices of respiratory activity.

Respiratory rates showed relatively high correlations with germination percentage. The principal deviations were due to three lots having a high proportion of seeds which initiated growth but failed to germinate and which had higher respiratory capacity at the early stage than expected from the germination percentages. There were no indications that oxygen consumption or carbon dioxide evolution mechanisms were differentially affected in lots of lowered viability.

Malic dehydrogenase activity was closely correlated with rate of oxygen consumption and roughly correlated with germination percentage. Lots having seeds which showed limited growth but high respiratory rates also had high malic dehydrogenase activity. Significant activity of this enzyme was present in seeds which were incapable of respiration and growth. Alcohol dehydrogenase activity was roughly correlated with both germination percentage and carbon dioxide evolution, although there was evidence to indicate that this enzyme was not limiting in either case. Cytochrome oxidase activity was quite variable and showed no clear relationship with either germination percentage or rate of oxygen consumption. Furthermore, activity of this enzyme was extremely low in comparison with both dehydrogenase activity and oxygen consumption.

The differences between cold tests and germination tests observed in several lots could not be related to deficiencies in any of the indices of respiratory metabolism measured. Similarly, differences in rates of germination could not be related to respiratory activity or activity of the three respiratory enzymes. Tetrazolium tests were in many cases higher than germination tests, perhaps a result of the retention of dehydrogenase activity in nonviable seeds. The evidence was insufficient to determine the extent to which malic and alcohol dehydrogenase were responsible for tetrazolium reduction by corn embryos.

An investigation of the factors affecting respiratory rates of corn embryos showed that tissue thickness, oxygen tension and immersion in phosphate buffer had a marked effect on respiratory capacity. The pericarp restricted gas exchange of whole seeds, resulting in respiratory quotients greater than unity. Seed residues had low but significant respiratory rates; however, these rates were due to tissue or tissues other than endosperm. Embryos from dry seeds had high enzyme content and exhibited relatively high respiratory rates when tissue was imbibed. Respiratory activity increased with time of soaking up to 18 hours, where no growth was evident, whereas malic and alcohol dehydrogenase activity increased only after growth began. Respiratory quotients of embryo slices decreased with soaking from unity for dry seeds to 0.77 and approached unity again after 27 hours.

[1]Doctoral thesis no. 1487, submitted December 13, 1953. Chairman of Committee, Frederick G. Smith, Department of Botany and Plant Pathology.

[2]B.S., New Mexico College of Agriculture and Mechanic Arts, State College, N.M., 1950. M.S., Iowa State College, Ames, Iowa, 1952. Graduate Assistant, Agricultural Experiment Station.

FARM RENTAL OBSTACLES TO LAND IMPROVEMENTS AND SUGGESTED SOLUTIONS[1]

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Where the costs of any input are borne by tenant or landlord and returns are not shared in the same proportion, inefficiency of resource use is fostered. These dissociations of cost and income are of two types, inter-temporal and intra-temporal.

This study is limited to the analysis of share-type leases, and the goal of a lease, as used in this study, is to allow the tenant farm to be operated as efficiently as an owner-operated farm with a comparable size of business. In line with this goal, the objectives are: (1) to establish what differences, if any, exist between the operation of physically similar, tenant- and owner-operated farms, (2) to determine the specific provisions of leases which cause tenants to farm in a manner different from owner-operators and to locate the provisions which enable certain tenants to operate as if they were owners, and (3) to set forth alternative lease provisions which would allow landlords and tenants more nearly to approach owner-operators in the efficiency with which they utilize farm resources.

Utilizing information from previous studies in the Ida-Monona soil association area of western Iowa, four groups of farms were selected for intensive study. Each group of farms was selected so that the farms in the group would be similar with regard to acreage, soil type and slope, climate, and total capital employed. One owner-operated farm was selected as the norm for each group. Of the six tenant-operated farms in the study, four were farms where it had been stated that the lease presented obstacles to efficient use of resources and, specifically, to the utilization of erosion control practices. Two of the tenant farms were selected as success farms, i.e., as having a landlord-tenant relationship which did not appear to restrict the efficiency of resource use below that of a comparable owner-operated farm.

The farming systems on the four obstacle farms were changed to correspond with those of the paired owner-operators at those points where it appeared that the lease might hinder a change in this direction. The effects of the revised plan and the present plan on the incomes of the landlord and tenant were estimated for a ten-year period. Also, the effect of the revised plan on the value of the farm after the ten-year period was estimated.

Crop yields for the different soil types under various rotations and erosion control practices were estimated with the assistance of members of the Iowa State College Department of Agronomy. Yields were not assumed to remain constant, but decreased, were maintained, or increased over time, depending on the soil loss due to erosion, the nitrogen added through legumes in the rotations, and the effect of fertilizer.

In all cases, the value of the revised plan (discounted at a rate of 5 per cent) was positive for the farm as a whole. On one 160 acre farm where the revised plan entails an increase of 36 acres of forage along with use of contouring on all fields, the landlord would absorb a loss in income over the ten-year period with present lease provisions. The tenant, on the other hand, would receive an estimated annual increase in returns of nearly $400.

It was estimated that the use of the revised farming systems on the four farms would increase farm value from about $4 to $21 per acre over the value if the present plan were continued for ten years. With inclusion of the farm value change, the revised plan would increase the returns to both the landlord and tenant on all four farms, but the tenant receives the greater increase under present leases.

Where large increases in forage acreage are put into effect, as was done on two of the four farms, the farm income may be decreased for two or three years. The crop-share tenant, utilizing the increased forage with additional livestock does not undergo any decrease in income; the landlord absorbs the reduction. Primarily, this is due to the low cash rent for hay and pasture on these farms.

To reduce the risk associated with fixed commitments of cash rent, the adoption of flexible cash rent based on changes in prices, costs, and production may be feasible,

[1]Doctoral thesis no. 1488, submitted December 13, 1953. Chairman of Committee, John F. Timmons, Department of Economics and Sociology.

[2]B.S., North Dakota State College, State College, N.D., 1950. M.S., Iowa State College, Ames, Iowa, 1951. Research Associate, Agricultural Experiment Station.

or the hay production could be shared just as is the proeuction of corn and oats.

To lengthen tenants' horizons of expectations, longer leases might be used. Another method is to assure the tenant of compensation for the unexhausted value of any improvements he should make. It appears that compensation provisions may give considerable impetus to the adoption of land and building improvements on rented farms.

Implementation of the findings of this study can be made at several levels. Education performs a vital role in disseminating information and in changing custom to allow more efficient lease provisions to be employed. Farm managers, public action agencies, and legislatures may encourage leasing adjustments through their own particular means. Tenants and landlords can, by means of a greater willingness to bargain, work out practical solutions to problems which are reducing the efficiency of resource use on their farms.

DISTRIBUTION OF THE FERTILIZER PRODUCTION FUNCTION IN RELATION TO DECISION MAKING[1]

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The purpose of this study was to explore the usefulness of knowledge of a sample of production functions in planning under uncertainty. A sample of production functions was estimated and these functions used to compare the results which would have been obtained from using several different procedures in planning.

Data for the study consisted of per acre yields of corn for varying rates of nitrogen on experimental plots at the Delta Branch Experiment Station, Stoneville, Mississippi. Rates of nitrogen used in the experiment were 0-45 pounds in 7.5 pound increments. The period covered by the data was 1921-1952.

Production functions for the experimental design were of the form $Y = f(X_1 \mid X_2 \mid X_3, X_4 \ldots X_n)$ where Y denotes corn yields, X_1 denotes nitrogen applied, X_2 denotes weather conditions, and $X_3, X_4 \ldots X_n$ denote the other factors of production. The vertical bars indicate nitrogen variable within years, weather conditions variable between years, and all other factors of production held constant. Five type functions were fitted to the annual data. Selection of the type function giving the best fit on the basis of the smallest mean square of the deviations from regression and logic resulted in the type function $Y = a + bX^2 + cX^3$ being chosen for 20 years, the type $Y = a + bX + cX^2$ for 7 years, the type $Y = a + bX$ for 3 years, and the types $Y = a + bX + cX^{\frac{1}{2}}$ and $Y = a + bX^2 + cX^{\frac{1}{2}}$ for one year each. In these functions Y refers to corn yields in bushels per acre and X refers to rates of nitrogen applied in 7.5 pound increments. All correlation coefficients for the annual functions selected, with a single exception, were significant at the 1 per cent level of probability. The other was significant at the 5 per cent level.

Responses due to the application of the different rates of nitrogen were obtained by (1) transforming the annual production functions into response functions (subtraction of the constant a in each production function from the production function) and (2) evaluating the resulting response to nitrogen functions at the rates of nitrogen used in the experiment. Under the assumption that weather conditions are random in nature, the responses thus obtained constitute a random sample of the responses obtainable from each rate of nitrogen applied.

In order to compare the results which would have been obtained from following several different procedures which may be used in planning the application of nitrogen to corn, functions were fitted to the mean, first quartile, median, and third quartile of the responses at the different levels of nitrogen. The same type functions as above were fitted and selection of the best fit on the same basis resulted in the type function $Y = a + bX^2 + cX^3$ being selected in each case. Correlation coefficients for these functions were significant at the 1 per cent level of probability.

Throughout the study it was assumed that prices were known and were constant.

[1]Doctoral thesis no. 1567, submitted June 4, 1954. Chairman of Committee, Earl O. Heady, Department of Economics and Sociology.

[2]B.S., Mississippi State College, Starkville, Miss., 1947. M.S., Ibid., 1950. Cooperator, Agricultural Experiment Station.

For purposes of comparison with results which would have been obtained from following several procedures in planning the application of nitrogen to corn, maximum profits from the use of nitrogen which would have resulted under perfect knowledge were calculated. In the first comparison of the different systems of planning, the average price of corn at harvest time for the 1921-1952 period (₡1.06 per bushel) and the average price of nitrogen in the form of Nitrate of Soda (₡1.17 per 7.5 pound increment) was used. In the second comparison, prices used were ₡1.06 for corn and ₡3.50 per 7.5 pound increment for nitrogen.

For the years for which a linear function or a function showing an area of increasing marginal productivity not followed by an area of decreasing marginal productivity within the range of observations, an infinite amount of nitrogen was indicated as the most profitable rate if its application were profitable at all. For these years, and for all other cases where the indicated most profitable rate was greater than the highest rate used in the experiment (six increments of 7.5 pounds), six increments were used for further calculations.

Planning procedures for the application of nitrogen compared were: perfect knowledge; last year's response function; functions for the second sixteen years to parallel the first sixteen and vice versa; best response function obtained during the period; poorest response function obtained; and the mean, median, first quartile, and third quartile response functions.

For the first comparison, very little difference in results which would have been obtained was indicated for several of the systems of planning. No losses from the application of nitrogen would have been realized under perfect knowledge or if plans were based on poorest responses. If either of the other systems of planning were used, however, losses would have been incurred two years of the 32-year period. Profits would have been highest under perfect knowledge, lowest if planning were done on the basis of poorest responses, and about the same for the other systems.

In the second comparison, the amount of nitrogen used under the various planning procedures would have been more dependent upon the procedure used in planning. Hence, there were wider differences in results which would have been obtained from following the different systems of planning. In terms of average profit per acre, however, four of the systems of planning (mean, median, first quartile, and third quartile) would have yielded about the same results. Parallel period planning would have resulted in the lowest average profits and the mean or median system the highest (except for perfect knowledge). No nitrogen would have been applied if plans were based on poorest responses. Consequently, there would have been neither profits nor losses under this system.

Losses would have occurred most frequently under parallel period planning and least frequently under the first quartile system. The latter system would also have resulted in the smallest maximum loss and the highest percentage return on money invested in nitrogen. It would appear, therefore, that this system of planning would yield best results for farmers with limited capital and alternative investment opportunities. Should the farmer have unlimited capital and wish to maximize profits over a period of years, it appears that he should plan in terms of mean or median responses.

ANALOGIES USING NON-IDENTICAL EQUATIONS[1]

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A method of establishing analogies between phenomena in which the characteristic equations are not identical has been presented. It differs from the usual procedure in that at least one of the equations relating variables in the model to the corresponding quantities in the prototype is nonlinear. The usefulness of this modified procedure is dependent upon a change in the form of a characteristic equation when functional transformations are used.

The dissertation includes a review of the changes in form of a second order differential equation that could be introduced by several specific types of functional transformations. In addition, a study was made of the methematical basis of the transformations and of the limitations imposed upon these transformations.

Three familiar examples were investigated theoretically using the modified system of establishing analogies, and the results were shown to agree with those given in the literature.

a. An analog circuit was designed to predict the deflection of a column. This use of a functional prediction equation made it possible to introduce resistance into the analog circuit even though the characteristic equation of a column does not contain a first derivative.
b. The analog circuit for predicting the behavior of a simple vibrating system was investigated. The theoretical solution showed that it was possible to predict an infinite deflection for an undamped system vibrating at resonance frequency even though the electrical system contains resistance and the electrical charge does not become infinite.
c. A third analog circuit was designed for any phenomena having Bessel's equation as its characteristic equations. The theoretical solution was shown to agree with the known solution to Bessel's equation of the plus and minus one-half orders.

In addition to the theoretical discussion of these three examples, the dissertation contains a description of the design, construction and operation of an electrical analog circuit for a beam column. The analog circuit was used to predict deflections of the beam column for five different loads. A photoformer was used in conjunction with a specially designed cathode follower amplifier having a low output impedance to supply an arbitrary voltage waveform to the analog circuit. The results of this investigation agree reasonably well with the analytical solution of the beam column problem using the theory of elastic stability. The error varied from 13 to 14 per cent, but a major of this discrepancy can be attributed to the improper operation of the experimental equipment.

[1]Doctoral thesis no. 1532, submitted May 27, 1954. Chairman of Committee, Glen Murphy, Department of Theoretical and Applied Mechanics.

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ANALYTICAL AND EMPIRICAL EVALUATION OF WATER TABLE BEHAVIOR AS AFFECTED BY DRAINAGE SYSTEMS[1]

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A field laboratory, designed to study the effect of the depth and spacing of tile drains on the rate of drawdown of the water table, was installed. The installation consisted of 15 parallel tile lines installed at two depths in a field of McPaul silt loam in such a manner that each line could be closed off or opened as desired and of a sheet metal barrier 6 feet deep all around the field.

The hydraulic conductivity, as measured in situ, of the upper 5 feet of soil was found to vary from about 10 to 20 feet/day, and from 5 to 5.5 feet deep, it was found that $K < 1.0$ foot/day. In the upper layer of 5 feet the soil was found to be anisotropic with a probable ratio $K_h/K_v = 3$.

By means of 3-inch core samples, the drainable porespace was determined as 5 per cent. Permeability determinations from the cores were unsatisfactory.

Numerous observations on the rate of drawdown of the water table from a position about 6 inches below the surface showed insignificantly small differences due to tile spacing. This phenomenon can partly be explained by the anisotropy of the soil, but was primarily due to the high rate of deep seepage loss. The deep seepage loss, accounting for close to 90 per cent of the total discharge, was probably the result of the extremely dry season. In a season more nearly normal than the past, it is expected that the natural water table outside the barrier would be sufficiently higher to reduce the amount of deep seepage to a value where it would not interfere with the comparison of drawdown rates due to tile spacing.

The assumptions of horizontal flow and of radial flow as they apply to the theoretical treatment of drainage problems were evaluated. Various solutions based on these assumptions were analyzed as to their advantages and weaknesses. It was shown that a judicious combination of assumptions of both radial and horizontal flow can lead to a valuable and reliable approximation of the actual steady state problem, but that the use of either assumption alone leads to serious inconsistencies in cases of steady as well as nonsteady state problems.

The analysis of steady state drainage problems by means of the hodograph method was investigated and Van Deemter's (1) hodograph solution was verified. It was shown that, although no objections can be raised against Van Deemter's treatment, his solution only applies to cases that are unlikely to occur in practice. It is restricted to unrealistically small drain diameters running under pressure.

Finally, several of the solutions criticized on theoretical grounds were tested against field observations. The field data used for these comparisons were gathered at different times and locations by different investigators.

The comparisons substantiated the previous findings that the solutions based on the assumption of horizontal flow deviated from the field conditions because of the omission of the convergence effect. The rate of change of the calculated spacings was less than that of the actual spacings, but when convergence was taken into account by a combination of the assumptions of radial flow and horizontal flow the rates of change of the spacings in the field and those determined theoretically were nearly equal. Furthermore, the actual spacings were generally less than those calculated when purely horizontal flow was assumed.

In view of the close agreement between calculations using Hooghoudt's (2) tables which are based on a combination of radial and horizontal flow assumptions and actual conditions, and considering the simplicity ot the use of these tables, it appears that this method can be recommended as the best available for the solution of steady state drainage problems.

The equations of Van Deemter deviated from the field observations in a manner attributable to the discrepancy between the actual size of the tile and the tile size required for the theory to apply.

[1]Doctoral thesis no. 1539, submitted June 1, 1954. Chairmen of Committee, Don Kirkham, Department of Agronomy, and R.K. Frevert, Department of Agricultural Engineering.

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Walker's (3) radial flow equation for the falling water table resulted in spacings far greater than found in the field. This again was in accordance with the theoretical discussion.

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ECONOMIC PRINCIPLE AS A GUIDE TO ADMINISTRATION AND TEACHING IN THE AGRICULTURAL EXTENSION SERVICE[1]

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The purpose of this study was to determine the applicability of existing economic principle to the problems of adminitration and teaching in the Agricultural Extension Service. As a problem of economics it was concerned with the most appropriate means to be used in order to achieve the alternative ends sought by extension administrators and field workers.

Cooperative Extension work qualifies as an economic problem because it involves maximizing ends relative to means. Such a problem may be one of resource allocation. It also involves the distribution of wealth because (1) it is publicly supported and thus, through taxation causes income transfers, (2) its services are not evenly distributed which causes income redistribution within the agricultural industry, and (3) its activities affect the prices of products and resources which influences income distribution throughout the entire economy.

The approach followed was first to study the environment in which resources are allocated and then to attempt to define the ends to be maximized. The implications from this approach can be seen by evaluating each part separately.

Legislation has been written in terms which limit administrative flexibility. From the standpoint of national administration, many problems which might otherwise involve choice are answered by statutory provisions. For example, the present policy which apportions funds to states chiefly on the basis of rural and farm population may differ from one based on marginal productivity. Efficiency criteria would suggest that adjustments be made in state allocations to permit equation of marginal value productivities. On the other hand, the present allocation may be rational on economic grounds. It it is assumed that the legislative body of a representative government accurately reflects the values of all people, then the present system may be a kind of optimum based on a particular system of values. The correctness of the answer depends on the selection of an appropriate choice indicator.

From the standpoint of state and local administration, institutional rigidities also exist. Despite this fact, new activities are added as old activities are discarded and economic principles are involved when the choice is made. The county agent adds a new activity when the expected returns exceed his expectations of returns in alternative existing lines.

The second phase of the study was to consider the resources used in the production of extension services. The production of the services of extension involves a variety of heterogeneous factors and a multitude of different immeasurable products. Whether

[1]Doctoral thesis no. 1469, submitted December 4, 1953. Chairman of Committee, Earl O. Heady, Department of Economics and Sociology.

[2]B.S., Michigan State College, Lansing, Mich., 1947. M.S., Ibid., 1949. Cooperator, Agricultural Experiment Station.

these various services are produced under conditions of increasing, constant, or diminishing returns to scale is not known with certainty. However, production involving increasing returns appears to be a plausible hypothesis. It is possible that public funds at the disposal of legislators are sufficiently limited to prevent the forcing of any one line of public service into an area of diminishing returns. If such is the case, any choice indicator one might wish to employ would indicate that the economic problem is to maximize the amount of financial resources available to Extension.

The third phase of this study was to evaluate the objectives of Extension. In general, the objectives were classified as (1) those chiefly concerned with the changes in individual values and levels of knowledge, and (2) those objectives concerned with efficiency in the use of resources and in the distribution of assets. These two general goals are in conflict because, in the first instance the object is to alter preference systems of individuals while, in the second case, a given constant preference system is a requisite of the efficiency criteria. Since both goals are upheld by extension workers, this condition represents a conflict in extension activity.

Important implications were drawn from analysis of objectives involving a change in the level of knowledge of individuals. The chief of these implications is that if an increase in production or an increase in utility is to be attained through education, then such education must be complemented by capital or some other resource.

In the analysis of objectives dealing with resource allocation and income distribution, attention was given the alternative goals of increasing agricultural efficiency and of increasing farm income. It was concluded that an extension program directed toward increasing agricultural efficiency should do the following things: (1) reduce uncertainty faced by farm operators, (2) assist in the transfer of "under-employed" resources in agriculture to other industries, (3) recognize that knowledge may be complementary with capital and that new measures may be necessary to facilitate the application of modern techniques an. ideas, and (4) assist in the removal of resource misallocation on low income farms.

Appropriate means to increase net farm income require a recognition of the relative inelasticity of demand for farm products. The following suggestions may be offered for a program based on maximizing agricultural income: (1) Monopoly practices aimed at reducing output. Resources in excess would need to be transferred to other industries. Extension workers would need to remember that (a) such a program would not attack the problem of income inequalities within agriculture and (b) it would conflict with the goal of maximum efficiency. (2) Extension workers would emphasize production of those commodities with the highest demand elasticity. (3) Efforts would be directed toward the transfer of resources out of agriculture. Activities which tend to fix labor on the farm would be avoided.

In summary, it becomes evident that the Extension Service cannot be all things to all people. There is a need on the part of policy-makers in Extension to resolve existing conflicts. After this is accomplished, economic principle can serve as a useful guide to the allocation of the resources expended in the achievement of the relevant ends.

THE EFFECT OF ORGANOMETALLIC AND QUATERNARY AMMONIUM COMPOUNDS ON THE GROWTH OF MICROORGANISMS[1]

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An investigation has been made of the effect of organometallic compounds on different aspects of the growth of microorganisms. A yeast, some molds, aerobic and anaerobic bacteria were employed in this study as representative samples of typical microorganisms to evaluate the inhibitory effects of different organometallic compounds. Extensive use was made of the yeast, Saccharomyces cerevisiae, because of its importance as a microorganism, its ease of cultivation and its availability. Other organ-

[1]Doctoral thesis no. 1523, submitted April 26, 1954. Chairman of Committee, L. A. Underkofler, Department of Chemistry.

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isms used included the bacteria, Acetobacter suboxydans, Lactobacillus delbrueckii, Lactobacillus casei, and Clostridium acetobutylicum; also the mold, Aspergillus niger. Growth conditions for these organisms were optimum in all instances except when altered by the addition of the organometallic compounds.

Preliminary studies were conducted with water-soluble compounds since they allowed maximum contact of the bacterial cells with the organometallic molecules in aqueous media. An organolead compound, tetrakis-(p-dimethylaminophenyl)-lead tetramethiodide, and a partially purified organotin dye, triphenyl-2-(p-carboxyphenylazo)-5-dimethylaminophenyltin, were found to be insufficiently soluble in water for the preparation of solutions which were toxic to the microorganisms, so other water-soluble organometallic compounds were tried.

The water-soluble organolead compounds, triphenyl-γ-(diethylmethylammonium)-propyllead methosulfate, was prepared and found to be toxic to all microorganisms at a concentration of 10^{-5} mole of compound per ml. of medium. The compound may derive its bacterididal properties from the nature of its quaternary ammonium structure which causes a reduction of the surface tension of media, or possibly by adsorption onto the surfaces of the bacterial cells.

A new compound, 4, 4, 4-triphenyl-n-butyldiethylmethylammonium methosulfate (called 444T for reference purposes), was synthesized by replacing the lead atom of the organolead methosulfate with a carbon atom by the following procedure: A benzene-ether solution of triphenylmethyl sodium was added to γ-diethylaminopropyl chloride and the excess reagent hydrolyzed following reaction overnight. The organic layer was dried and excess solvent removed. Reaction with dimethyl sulfate gave white crystals of 444T after recrystallization from acetone. M.P. 161-162°C.

The 444T was less toxic than its lead analog. A concentration of 10^{-7} mole of the organolead compound per ml. of medium caused a great reduction in the rate of respiration of S. cerevisiae within 30 minutes, while 444T at the same concentration produced no inhibition. Similarly, 444T allowed 11.1 per cent glucose uptake, but the lead analog produced complete inhibition of glucose metabolism.

The alkyl ammonium methosulfate portion of 444T, i.e., n-propyldiethylmethylammonium methosulfate, was prepared. It was relatively nontoxic to some molds in contrast to the organolead compound and its carbon analog. A concentration of 10^{-5} mole of the compound per ml. of medium inhibited some bacterial growth, but allowed the growth of some air-borne molds. All three methosulfate compounds caused cell agglutination with S. cerevisiae; this was perhaps due to neutralization of the zeta potential of the cells by the positive charge of the cationic portion of these molecules.

Preliminary studies of these quarternary ammonium compounds were conducted with air-borne molds obtained from a glucose-yeast extract medium which had been exposed to the atmosphere. The use of very low concentrations of the organolead methosulfate (10^{-9} to 10^{-11} mole per ml. of medium) with these molds produced increased rates of glucose uptake, while higher concentrations caused increased metabolic inhibition. The mold, Aspergillus niger, was affected in the same manner by these compounds.

The use of organometallic water-insoluble compounds required a preliminary search for organic solvents which were miscible with water, nontoxic to microorganisms, and good solvents for such compounds. Among those tested were Butyl Cellosolve, ethanol, acetal, dioxane, and ethyl lactate. The low toxicity of dioxane to the cells of S. cerevisiae was unexpected. This organism grew well in any concentration of dioxane up to 4 per cent, whereas diethyl ether, a compound of similar structure, is very toxic to yeast. Solvent controls were used in all fermentations. The water-insoluble organometallic compounds which were studied included diphenylmercury, triphenylbenzyllead, triphenyl-p-tolyllead, and triphenylsilanol. Tetraphenyllead and tetraphenyltin were too insoluble in the water-miscible solvents required, so they could not be tested.

Respiration of some aerobes suffered 100 per cent inhibition within 30 minutes after the introduction of the organometallic compounds. These studies revealed some instances in which the metabolism of the cells was halted, while their respiration continued, as when the cells of S. cerevisiae were treated with triphenyl-p-tollyllead.

Support for the theories of the mode of action of diphenylmercury and triphenyl-p-tolyllead against microorganisms was obtained from the results of experiments which were conducted with BAL (British antilewisite). The BAL was ineffective when used with diphenylmercury; no decrease of toxicity resulted, but BAL appeared to reduce the inhibition of glucose metabolism by triphenyl-p-tolyllead when it was used with S. cerevisiae and L. casei.

The water-soluble methosulfates produced a sluggish fermentation by the anaerobe, Cl. acetobutylicum, while increased acid production and an abnormal increase of glucose resulted from the addition of diphenylmercury of triphenyl-p-tolyllead to the medium used with this organism.

All organometallic compounds of lead or mercury were toxic to all of the microorganisms tested. An exposure of only 5 minutes was sufficient for complete loss of cell viability when diphenylmercury was added to a medium. The quaternary organolead methosulfate required 45 minutes to exert the same degree of inhibition.

TOPCROSS AND POLYCROSS PROGENY TESTS FOR EVALUATING GENERAL COMBINING ABILITY OF S_0 AND S_1 CLONES OF ORCHARDGRASS, DACTYLIS GLOMERATA L.[1]

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Different types of progeny from a group of 12 S_0 and 12 S_1 clones of orchardgrass were compared to determine which progeny test was the most effective for measuring general combining ability and to obtain information on randomness of pollination in nurseries used for outcross seed production. Topcross seed was obtained from nurseries containing alternate rows of space-planted clonal material and drilled seedings of a commercial lot of orchardgrass, the latter served as a common source of pollen. Isolated crossing blocks were used to produce polycross seed, while open-pollinated seed from S_1 clones was obtained in an inbred nursery where each S_1 clone was planted in a row with a number of its sibs. All progenies (222 entries) were planted in broadcast plots in the same experiment using a randomized complete block design with three replications. Green forage yields were taken from two crops in 1951 and 1952, and separate variance analyses were made for each crop, for total annual yield, and for the combined two-year total yield. Data on panicle production were obtained once each year. Progeny investigations were analyzed as three separate tests: (1) Topcross Raplicate Test, including topcross and polycross progenies of 12 S_0 clones, (2) Polycross Replicate Test made up of the polycross progenies of seven of the same 12 S_0 clones, and (3) S_1 Topcross Replicate Test which included the topcross and open-pollination progenies of 12 S_1 clones. Seed from various replications of the topcross nurseries and from two polycross nurseries was kept separate to compare effectiveness of different replicate entries for evaluation of combining ability and to obtain information relating to randomness of pollination. Also, a comparison was made between topcross and open-pollination progenies of S_1 clones, in which the open-pollination progenies were not subjected to equal or random pollination.

Differences among clones in general combining ability for yield were consistently detected by replicate topcrosses in the Topcross Replicate Test. Polycrosses differentiated clones in four instances and bulk topcrosses in one out of a total of seven analyses each. All types of progenies showed significant differences among clones in combining ability for panicle number in every instance. In the Polycross Replicate Test the clones were found to differ in combining ability for forage yield in 1952 and for the two years combined. They also differed in both years for panicle number. S_1 clones in the S_1 Topcross Replicate Test also varied in combining ability, though neither topcross nor open-pollination progenies consistently detected differences for forage yield. Significant differences in panicle number were revealed by both types of progeny.

Replicate topcrosses were more sensitive for evaluation because they were represented by 24 plots per clone as compared to three per clone for bulk topcrosses and polycrosses. For both yield and panicle number estimates indicated that the greatest amount of information would be obtained with one replication in the test and 24 in the topcross nursery. Estimates of relative information for panicle number with 24 rep-

[1]Doctoral thesis no. 1494, submitted December 14, 1953. Chairman of Committee, Robert R. Kalton, Department of Agronomy.

[2]B.S., Iowa State College, Ames, Iowa, 1949. M.S., Ibid., 1951. Research Associate, Agricultural Experiment Station.

lications in the test and one in the nursery were 38 per cent and 21 per cent for 1951 and 1952, respectively, while corresponding information for yield was 100 per cent and 75 per cent for the same two years. The effect of keeping replicate entries separate was much more pronounced for the more heritable character, panicle number. It was estimated that nine replications for bulk topcross entries and 12 for polycross entries would be necessary to attain the same relative precision as obtained with replicate topcrosses for panicle number. The same estimates for yield ranged from 18 to 50 for bulk topcrosses and 18 to 30 for polycrosses.

Within clone variances from analyses of variance of the data were frequently significant, indicating that the sample of pollen received by plants in the various replications was not equal or random. In the Topcross Replicate Test they were significant in 1952 and for the two years combined for panicle number. Those for forage yield were significant only for the first crop of 1951. Deviations due to male parentage were not significant for either panicle number of forage yield in the Polycross Replicate Test, while in the S_1 Topcross Replicate Test only panicle number appeared affected by unequal male parentage.

Interprogeny correlations were high between mean performance of replicate topcross progenies of 12 S_0 clones in the present investigation and mean singlecross performance of the same clones in an earlier study. The correlations, based on two-year means, were 0.86 and 0.80 for forage yield and panicle number, respectively. Accuracy of mean estimates, because of the large number of plots which were used to evaluate the clones in each of the two tests, probably were responsible in a large measure for these high correlations. Therefore, with sufficient replication, the topcross test generally ranked the clones in the same order as the mean of all singlecrosses and provided a good measure of general combining ability.

Interannual correlations were positive for both yield and panicle number of parents and of their progenies in the Topcross Replicate Test. Associations for parents were significant and high for both yield and panicle number while those for progenies were generally low and nonsignificant for yield. Panicle number correlations for replicate topcrosses and polycrosses were significant at the 5 per cent level. Years x entries interactions were significant in all analyses in the Topcross Replicate Test. These low associations in the progeny tests, especially for yield, and the significant years x entries interactions emphasize the importance of evaluating progenies for at least two years or more.

In the discussion and interpretation of the results it appeared possible from a breeding standpoint to test a much larger number of clones by use of the topcross test rather than the polycross test with the same relative expenditure of time and effort. Effects of nonrandomness of pollination could be overcome by mixing equal amounts of seed from each replication. Sufficient replicates would have to be included in the topcross nursery to produce required amounts of seed, but this generally would not be nearly the number required in a polycross nursery to insure an approach to equal pollination.

THE GENESIS AND MORPHOLOGY OF SOME TRANSITIONAL BRUNIZEM - GRAY-BROWN PODZOLIC SOILS[1]

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Field and laboratory studies were made of some soils which have morphological characteristics that are intermediate to those of the Brunizem and Gray-Brown Podzolic soils. The transitional Brunizem - Gray-Brown Podzolic soils are presumably formed by the encroachment of deciduous trees on Brunizem soils. The latter were developed under prairie. Thus, the transitional soils are the middle member of a soil biosequence and their morphology results from a change of the biotic factor of soil formation.

[1]Doctoral thesis no. 1463, submitted November 30, 1953. Chairman of Committee, Frank F. Riecken, Department of Agronomy.

[2]B.S., Iowa State College, Ames, Iowa, 1948. M.S., Ibid., 1950. Research Associate, Agricultural Experiment Station.

Field studies indicate that there is a gradual change from the Brunizem soils to the Gray-Brown Podzolic soils within most traditional soil areas. The first visible morphological change induced by trees in the Brunizem soils appears to be the development of grayer colors in small localized areas in the lower part of the dark colored granular A horizon. The dark color disappears from the A_2 horizon and the structure changes from granular to platy units as the Brunizem soil traits become less evident. The formation of the platy structure in the A_2 horizon probably occurs simultaneously with the loss of clay from the horizon and with the formation of a thinner dark colored A_1 horizon. The thin dark A_1 horizon becomes lighter colored as the transition soil develops into a Gray-Brown Podzolic soil with stronger subangular blocky structure peds in the B_2 horizon.

The laboratory analysis for total carbon and nitrogen substantiates the decrease in organic matter of the lower A_1 horizon as was indicated by the morphological changes observed in the field. The loss of organic matter in the incipient A_2 horizon of the transitional soils studied was accompanied by a decrease in pH, per cent base saturation, clay content and the ratio of exchangeable calcium to magnesium. With regard to these properties in the lower A horizon, the Brunizem soils had the highest values, the transitional soils had intermediate values and the Gray-Brown Podzolics had the lowest values. The Gray-Brown Podzolic profiles had less clay in the A horizon than the associated Brunizem profiles while their transition profiles had an intermediate amount. The Gray-Brown Podzolic and associated transitional profiles of a biosequence had about the same maximum per cent clay in the B_2 horizon while the associated Brunizem profile contained slightly less clay in that horizon. The ratio of the minimum per cent clay in the A horizon to the maximum per cent clay in the B horizon apparently indicates the degree of profile development of the soils of the biosequences studied, with the ratio being highest in the Brunizem profile, intermediate in the transitional profile, and lowest in the Gray-Brown Podzolic profile. The exchangeable calcium-magnesium ratio in the A_2 or lower A_1 horizons appears to be another measure of the degree of development in the profiles. It seems the clay and calcium-magnesium ratios are probably comparable indicators of profile development in soils which have a uniform parent material such as loess.

The per cent base saturation, pH, exchangeable calcium, and the ratio of exchangeable calcium to magnesium increase in the A_1 horizon of the transitional profiles as compared to the Brunizem profiles. It appears, from available data, that more calcium is returned to the soil surface in the annual leaf fall of deciduous forests than from the annual death of the prairie forage. This additional calcium would account for the changes which occur in the A_1 of the Brunizem soils which have become transitional soils. The Gray-Brown Podzolic profiles had a lower pH, per cent base saturation, and quantity of exchangeable calcium in the A_1 horizon than the transition profiles.

The transitional soils have laboratory and morphological properties intermediate to the Brunizem and Gray-Brown Podzolic associates. It is postulated that a new Great Soil Group would simplify the classification of these transitional Brunizem - Gray-Brown Podzolic soils.

CROSS-INCOMPATIBILITY IN MAIZE[1]

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Some popcorn varieties fail to set seed when pollinated by other varieties of popcorn or by dent corns, but are cross-compatible when used as male parents.

A knowledge of the mechanism of cross-incompatability has become important from the standpoint of hybrid popcorn seed production. Many of the better popcorn hybrids are three-way crosses of the type (Supergold x Supergold) x South American. Crosses of this type must be made with Supergold inbreds as female parents since South Ameri-

[1]Doctoral thesis no. 1480, submitted December 9, 1953. Chairman of Committee, I. J. Johnson, Department of Agronomy.

[2]B.S., Brigham Young University, Provo, Utah, 1949. M.S., University of Arkansas, Fayetteville, Ark., 1951. Cooperator, Agricultural Experiment Station.

can inbreds used as female parents are incompatible with Supergold inbreds. Supergold inbreds also are fully compatible with dent corn. In areas where it is difficult to isolate popcorn seed fields from dent corn, outcrosses with dent corn become a problem since they cannot be detected in the seed crop. Transfer of genetic factors for cross-incompatibility to compatible inbreds would thus serve to prevent dent-contamination.

Results of previous research indicate that the genetic basis for cross-incompatibility is a series of multiple alleles at the ga locus on the fourth chromosome. The mechanism involved is believed to be a reaction between the diploid style and haploid pollen-tube whereby the growth of ga pollen-tubes is completely inhibited in $Ga^{S}GA^{S}$ silks and retarded in $Ga^{S}ga$ silks so that ga pollen-tubes rarely affect fertilization in competition with Ga^{S} pollen-tubes.

The purpose of this study was to determine the extent and nature of cross-incompatibility among several inbred lines of popcorn and dent corn and to study further the genetic mechanism involved. Pollination tests were made using cross-incompatible popcorn inbreds as female parents in crosses with compatible popcorn and dent corn inbreds. Four or five hand pollinations were made of each cross, and the resulting number of kernels per ear recorded. In addition, F_2 and backcross populations from crosses involving incompatible and compatible inbreds were tested for receptivity to dent corn pollen. Plants with less than 30 per cent seed set were considered nonreceptive, 30-70 per cent as doubtful, and those with more than 70 per cent as receptive to dent corn pollen.

The incompatible popcorn inbreds all reacted in a similar manner when pollinated by either compatible popcorn or dent corn inbreds. However, the variability in number of kernels per ear was considerable and appeared to be subject to environmental influence. When a small amount of seed was set, it usually was found at the tip of the ear, thus substantiating the hypothesis of inhibition of pollen-tube growth as the physiological explanation of cross-incompatibility.

F_2 populations from crosses among incompatible inbreds did not segregate for receptivity to dent corn pollen, thus indicating these lines had genetic factors in common conditioning cross-incompatibility. Similarly, F_2 populations from crosses among compatible popcorn inbreds were fully receptive to dent corn pollen, indicating they had genetic factors in common conditioning cross-compatibility.

Some F_2 populations from crosses between compatible and incompatible inbred lines segregated approximately in the ratio of one receptive to one nonreceptive plant. This substantiated the Ga^{S}- ga classification as being the genetic mechanism involved. Others deviated widely from the expected 50 per cent nonreceptive plants, ranging from 2.2 to 100 per cent.

Backcross populations of the type (compatible x incompatible) x incompatible deviated considerably in some cases from the expected 50 per cent nonreceptive plants. When the F_1 was backcrossed as the male parent to the incompatible inbred, the progenies were generally nonreceptive to dent corn pollen.

Backcrosses of the F_1 to the compatible inbred parent generally produced progenies which were receptive to dent corn pollen regardless of which way the backcross was made.

The performance of F_1, F_2, and backcross populations involving the popcorn inbred, W5, and the dent inbred, 4Co63, indicated that in this case plants of the genetype $Ga^{S}ga$ completely inhibited the growth of ga pollen-tubes even in the absence of competing pollen.

F_2 and backcross populations involving reciprocal single crosses usually segregated alike, indicating that a cytoplasmic influence was not operative in this type of cross-incompatibility.

Both compatible and incompatible inbreds appeared to possess genic differences in the form of alleles differing from the type Ga^{S} or ga and/or genes which modify the compatibility reaction.

POSTEMBRYONIC DEVELOPMENT OF THE OVARIES OF ONCOPELTUS FASCIATUS (DALLAS)[1]

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This investigation was undertaken to determine the histogenetic development of the ovarian tissues of the milkweed bug. It was hoped that this knowledge would make clear the origin of the diverse tissues found in the adult ovariole and that it would eliminate some of the confusion concerning the origin of ovarian tissues in the Heteroptera.

All of the tissues present in the adult ovary have been derived from four tissues present in the first instar nymph at the time of hatching. These undifferentiated tissues are: the anterior ovarian strand, the posterior ovarian strand, the primary epithelial sheath and the oogonia.

The anterior ovarian strand, as the result of growth and differentiation, produces the terminal filament.

The posterior ovarian strand produces the prefollicular primordium and the pedicel in the third nymphal instar. In successive nymphal stadia the prefollicular primordium produces prefollicular tissue which in turn produces the definitive follicular epithelium. Thus the follicular epithelium and the pedicel can be traced back to undifferentiated mesodermal tissue.

The primary epithelial sheath eventually produces the outer epithelial sheath and the inner envelope of the adult ovariole.

The oogonia produce the oocytes and the apical trophic tissue. The critical divisions of the oogonia that produce these two tissues begin in the fourth nymphal stadium and continue into the fifth stadium.

Not all of the oogonia produced during the nymphal development of the ovariole are retained. Some of the oocytes are displaced into the prefollicular tissue and accumulate as a mass of cells at the anterior end of the pedicel. The displaced germ cells are discharged into the lumen of the pedicel in the fifth nymphal stadium.

[1]Doctoral thesis no. 1522, submitted April 19, 1954. Chairman of Committee, Philip F. Bonhag, Department of Zoology and Entomology.

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THE VANADIUM-ZIRCONIUM ALLOY SYSTEM[1]

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The equilibria existing in the vanadium-zirconium alloy system were investigated by means of solidus temperature determinations, thermal analysis, dilatometry, electrical resistance measurements, metallography, and X-ray diffraction methods.

Solidus temperature determinations showed a eutectic reaction between a zirconium-rich solid solution and a compound, V_2Zr, at a temperature of $1230^\circ \pm 10^\circ C$. V_2Zr was found to decompose into liquid and a vanadium-rich solid solution at $1300^\circ \pm 25^\circ C$. The eutectic composition was determined to be near 30 per cent vanadium by weight from metallographic evidence.

The eutectoid reaction between V_2Zr and alpha zirconium was shown to take place by thermal analysis, dilatometry, and electrical resistance measurements. The electrical resistance measurements gave $777^\circ \pm 5^\circ C$ as the eutectoid temperature and 5 per cent $\pm$ 0.5 per cent vanadium by weight as the eutectoid composition. The measurements indicated that possible existence of an impurity in the alloys, however.

The composition range of V_2Zr was shown to be very small by metallographic

[1]Doctoral thesis no. 1537, submitted May 28, 1954. Chairman of Committee, B.A. Rogers, Department of Chemistry.

[2]B.S., Hamline University, St. Paul, Minn., 1944. M.S., University of Minnesota, Minneapolis, Minn., 1949. Research Assistant, Institute for Atomic Research.

methods, and it was found to be near 52.8 weight per cent vanadium, the stoichiometric composition for V_2Zr.

X-ray diffraction analysis of alloy powders indicated no transformation in V_2Zr and no other intermediate phase in the system. The lattice type for V_2Zr was not determined.

Some metallographic evidence was obtained which showed a limit of solubility of zirconium in vanadium of less than five per cent by weight at 600°C and more than five per cent at temperatures above 800°C. The evidence was poor because the alloys appeared to contain material foreign to the system.

ECONOMIC ANALYSIS OF PROTEIN-GRAIN SUBSTITUTION RELATIONSHIPS IN PORK PRODUCTION[1]

ROGER CHARLES WOODWORTH[2]
Department of Economics and Sociology

This study departs from traditional procedures in determining protein levels for hog rations. It is conceived within an economic framework beginning with the conceptual stage, through the design and carrying out of feeding trials and the analysis of data. The primary objective was to establish, by means of feeding trial data and multiple regression analysis, the replacement power of soybean oil meal for corn with various levels of protein in the ration. Other objectives were to relate protein level with the time required to reach market weight and with optimum marketing weight.

The study is based on three feeding trials with a combined total of 464 pigs. All lots received a basic corn-soybean oil meal ration fortified with vitamins (including vitamin B_{12}) and minerals. The analysis was carried out for rations with and without antibiotics.

From these data, regression equations of the general form $Y = f(C, P)$ were derived to predict pig gains with use of different quantities of corn and soybean oil meal, where Y is gain per pig, C is pounds of corn per pig and P is pounds of soybean oil meal per pig. Equations were then derived to obtain (1) marginal gain functions for different rations to show the added gain per added pound of feed, (2) the different combinations of corn and soybean oil meal which would result in a desired gain (iso-product equations) and (3) the rate at which soybean oil meal substitutes for corn at different pig weights and different combinations of corn and soybean oil meal.

The relationships between per cent protein in the ration and time to obtain given weight were obtained through regression equations of the general type $T = f(C, P)$, where T refers to total time in days, C refers to pounds of corn and P refers to pounds of soybean oil meal. These equations in conjunction with the gain equations allow predictions of (1) time to reach market weight, (2) average daily gain, and (3) added gain for an added day's feeding.

Comparisons are made from the employment of several alternative equations including the Cobb-Douglas, quadratic cross-product, quadratic square root and quadratic ratio equations. The Cobb-Douglas equation was fit over the weight range from weaning to 200 pounds (over-all equations) and also for the weight ranges from weaning to 75 pounds, 75 to 150 pounds, and 150 to 200 pounds (interval equations). While a completely objective means of choosing the most appropriate equation is not available, it would appear from looking at the statistical tests, scatter diagrams, and the logic involved in each equation, that the interval equations are more appropriate than the over-all equations. It appears that the interval Cobb-Douglas, quadratic square root or quadratic ratio equations are more appropriate for this data than the other two equations tested. The interval Cobb-Douglas gain equations and the quadratic square root time equations were selected for use in this study. Comparisons were also made for the different experiments and for rations with and without aureomycin.

The data derived through the regression equations are used to specify (1) least-cost rations, (2) optimum marketing weight, and (3) least-time rations; and to analyze maximum profit rations for hogs of different weights.

[1]Doctoral thesis no. 1544, submitted June 2, 1954. Chairman of Committee, Earl O. Heady, Department of Economics and Sociology.

[2]B.A., University of New Hampshire, Durham, N.H., 1948. M.S., Iowa State College, Ames, Iowa, 1951. Graduate Assistant, Agricultural Experiment Station.

A ration is least-cost when the price ratio of the two feeds is inversely equal to the substitution rate. Starting with the price ratio (price of soybean oil meal/price of corn) one can easily determine the least-cost ration, the length of the feeding period, the added cost of the least-time ration and other relevant data needed in making decisions. Thus, if soybean oil meal costs twice as much as corn, the least-cost-ration is that level of protein at which one pound of soybean oil meal would replace two pounds of corn. This would be a 16.0 per cent protein for small pigs, 11.3 per cent for the intermediate weights, and 10.1 per cent for the heavy weights. It would take 609 pounds of corn, 60 pounds of soybean oil meal, and 121 days to get a 34 pound pig in the market at 225 pounds. This would be a feeding period 16 days longer than would be required for the least-time ration requiring 527 pounds of corn and 131 pounds of soybean oil meal. This data is presented in (1) table form, (2) a slide rule wheel, and (3) the nomograph approach.

Tables are presented to assist in determining the added costs and returns from adding 25 pounds of gain to 175 and 200 pound hogs with different rations. This is done by indicating the selling price needed to break even if the 25 pounds were added, in contrast to marketing the hogs at the lighter weight.

Costs and returns are presented for the past 16 years, comparing the least-cost and least-time rations for November 1st and November 15th farrowing dates. For a November 1st farrowing date, there was only one year out of the 16 where the least-time ration was more profitable than the least-cost ration. For the November 15th date, there were two years for which the least-time ration was more profitable.

Multiple correlation coefficients, standard errors and values of t for statistical tests of significance are listed in the appendix.

CROSS COMPATIBILITY RELATIONSHIPS AMONG SPECIES OF AVENA[1]

FRANCIS JOHN ZILLINSKY[2]
Departments of Agronomy and of Genetics

Although considerable information has accumulated from other investigations, the relationships among the chromosomes of the three karyological groups of the genus Avena have not yet been definitely established. Crosses were made among eight Avena species representing the diploid, tetraploid, and hexaploid groups. The percentage seed set of the crosses and the relative self-fertility of the F_1 hybrids were determined. Crosses which failed to produce seed and hybrids which were sterile on selfing were studied to determine the most critical stages at which failures of the reproductive processes occurred.

Other factors which had a direct bearing on the problem also were studied. As polyploidy is the most effective means of overcoming sterility in hybrids, it was of interest not only to produce polyploids of the hybrids but also to determine the most effective and practicable methods by which chromosome doubling can be obtained in oats. Six methods using colchicine and one using acenaphthene were investigated. Several crossing techniques also were studied to determine their effect upon seed set and degree of outcrossing.

Intraspecific crosses and interspecific crosses among species having the same chromosome number set seed readily. The percentage of germination of the seed was very high and the F_1 hybrids were highly self-fertile. A lower percentage of the crosses between tetraploid female x hexaploid male and tetraploid female x diploid male produced seed. The seed, however, germinated readily but the F_1 hybrids were highly sterile on selfing. When the hybrid was used as the female parent, seed was obtained by backcrossing to both of the parental species. Crosses between hexaploid female x tetraploid male produced only a few seeds, all of which failed to germinate. It was not determined whether the failure to germinate was due to dormancy or inviability of the seeds. Normal seeds were not obtained from crosses between hexaploid female x dip-

[1]Doctoral thesis no. 1549, submitted June 3, 1954. Chairmen of Committee, Joseph G. O'Mara, Department of Genetics, and I. J. Johnson, Department of Agronomy.

[2]B.S.A., University of Saskatchewan, Canada, 1949. M.Sc. Ibid., 1950. Cooperator, Agricultural Experiment Station.

loid male, diploid female x tetraploid male, and diploid female x hexaploid male. Hybrids of the cross hexaploid female x diploid male have been reported by other investigators. Failure to obtain these hybrids in this investigation may have been due to too few crosses attempted, the varieties used in the crosses, or to inadequate technique.

The most critical stage in the reproductive processes between cross-pollination and ripening of the hybrid seed occurred at, or immediately after, fertilization. Although crosses between A. strigosa x A. sativa failed to produce normal seed, 28.5 per cent of all cross-pollinations resulted in fertilization and initiation of embryo and endosperm development. The progress of ovary development was determined by preparing sections of the ovary taken at intervals of two, four, eight, and fifteen days after pollination and comparing the hybrid ovary development with that of the two parents. Embryo development in the hybrid was comparatively normal in the early stages of development and continued to grow up to eight days after pollination. Abnormal development in the hybrid endosperm was observed at two days after pollination and remained abnormal until degeneration and complete collapse of the hybrid caryopsis resulted.

Failures in the development of viable gametes in the hybrid plants resulted from abnormalities at meiosis. These effects were considerably more harmful to the male gametes than to the female gametes, as determined by the higher seed set in backcrossing than in selfing. Microscopic observations on pollen condition provided a good estimate of the male fertility of the hybrid.

Of the several methods studied to induce chromosome doubling in oats, the most efficient and generally satisfactory, was the capping method. When tillers of the young plants reached the two- to three-leaf stage they were cut off about one to two inches above the soil and capped for 24 hours with a glass vial containing 0.1 per cent aqueous colchicine solution. Usually only some sectors of the plants were doubled. All attempts to induce doubling with acenaphthene failed.

The following artificial polyploids were produced by colchicine treatment: autopolyploid of A. strigosa (2n = 28); amphiploid of A. abyssinica x A. strigosa (2n = 42); amphiploid of A. abyssinica x A. sativa (2n = 70). Morphological differences between the autotetraploid and normal diploid of A. strigosa were: increased stomata and pollen size, increased length of the spikelet and reduced fertility. The amphiploid tillers of the hybrids were morphologically very similar to the undoubled tillers except for improved pollen condition and increased self-fertility. The polyploids were not completely fertile on selfing and ranged from 30 to 60 per cent of the parental varieties.

Crosses were made between the autotetraploid of A. strigosa and species from different groups to determine if doubling the chromosome number affected the seed set following cross-pollination and the fertility of the resulting hybrids. When used as the female parent, the autotetraploid A. strigosa produced seed more readily than did the diploid in crosses with the tetraploid and hexaploid species. The hybrid of the autotetraploid A. strigosa x A. abyssinica was very vigorous and partially self-sterile. Crosses between autotetraploid A. strigosa x the hexaploid species set seed readily but the hybrids were self-sterile. Triploids from the cross autotetraploid x diploid A. strigosa were easily obtained, vigorous, and partially fertile on selfing.

The study of crossing techniques provided some useful information towards improving efficiency in hybridization, but no new techniques were discovered to overcome the failure to obtain hybrid seed in certain crosses by the standard crossing methods. Although a slightly higher seed set was obtained when crossing was done without the removal of the secondary floret, or without the protection of a glassine bag after pollination, a higher incidence of outcrossing accompanied the use of these methods under field conditions. A very low frequency of outcrossing was obtained under greenhouse conditions. The effect of time of day was more pronounced upon the availability of ripe pollen than upon seed set following pollination.

MASTERS' THESES

MASTERS' THESES

Accepted July 1, 1953 - June 30, 1954

SUMMARY AND INDEX

The following summaries and indices may prove helpful to those interested in tabulations and to those who may wish to examine theses in the same or related fields.

Index to Masters' theses by departments. The departments are arranged alphabetically. Under each department are listed alphabetically the names of the authors.

Masters' theses accepted July 1, 1953 - June 30, 1954 = 181.

Aeronautical Engineering - Total 1. Rowe.

Agricultural Engineering - Total 2.
Bichel, Herum.

Agronomy - Total 11.
Allos, DeLong, dos Santos, El Banna, Green, McCarts, Nelson, N.M., Smith, C.M., Sutherland, Verma, Willis.

Animal Husbandry - Total 12.
Acker, Blackmore, Douce, Lewis, C.J., Lodge, Roberts, Rohlfe, Skinner, Taylor, Torres, Tsien, Wickersham.

Applied Art - Total 1. Harvey.

Architectural Engineering - Total 2.
Rogness, Winterowd.

Bacteriology - Total 2. Bell, Brennan.

Botany and Plant Pathology - Total 4.
Dale, Hampton, Hilton, Morrill.

Ceramic Engineering - Total 1. Nadler.

Chemical Engineering - Total 4.
Burzlaff, Cowles, Davy, Hall.

Chemistry - Total 13. Borchers, Borduin, Calamari, Deal, Debbrecht, Diehl, Dooley, Edwards, Ford, Grantham, Jaselskis, Kniseley, Serat.

Child Development - Total 4. Carroll, Lewis, D.B., Meyer, Quiambo.

Civil Engineering - Total 5. Bailey, Cebula, Coad, Girtner, Phillips.

Dairy Industry - Total 2.
Brandsaeter, Papadopoulos.

Economics and Sociology - Total 12.
Boehnke, G.E., Brown, du Toit, Halter, Hoover, Hunter, McKee, Macy, Maki, Ose, Smith, D.J.G., Voth.

Electrical Engineering - Total 1.
Dorsman.

Food Technology - Total 1. Fortney.

Foods and Nutrition - Total 3.
Foss, Samvik, White.

Forestry - Total 1. Hertzberg.

General Engineering - Total 5. Courson, Field, Korbitz, Pletke, Stanley.

Genetics - Total 4.
Banach, Blackmore, Fortney, Graf.

Geology - Total 4.
Giltner, Handy, Tench, Weissmann.

History and Government - Total 1.
Seaton.

Home Management - Total 6.
Bonnett, Leupold, Nelson, L.J., Paulsen, Singer, Vergin.

Horticulture - Total 4.
Kirk, Plaisted, Reiling, Schark.

Institution Management - Total 2.
O'Herron, Stebbins.

Mathematics - Total 1. Low.

Mechanical Engineering - Total 1. Ewen.

Physics - Total 9. Barson, Blue, Damask, Davey, Heemstra, Jones, Olson, Phipps, P.L., Snyder.

Psychology - Total 8.
Brooks, Bruns, Clampitt, Martinek, Maxson, Mosing, Thrall, Truesdell.

Statistics - Total 6. Bose, Cox, Jacobs, Kwolek, Meshadani, Pauls.

Technical Journalism - Total 1. Heer.

Textiles and Clothing - Total 1. Lyle.

Theoretical and Applied Mechanics - Total 1. Lewis, R.W.

Veterinary Anatomy - Total 1.
Worthman.

Veterinary Obstetrics - Total 1.
Reuber.

Veterinary Physiology - Total 2.
Holloway, Worthman.

Vocational Education - Total 32.
Barker, Bartow, Beavers, Bloss, Busjahn, Canfield, Cathey, Douce, Ferguson, Gard, Goche, Hamilton, Hartel, Krieguer, Little, Littlefield, Martens, Perez, Phipps, R.G., Pippett, Rhetta, Schaefer, Shadle, Smith, M.E., Sorenson, Spratt, Steinert, Stone, Tschopp, Vest, Weekley, Zink.

Zoology and Entomology - Total 13.
Boehnke, R.H., Crunden, Downes, Hennemuth, Kelton, Klongan, Luce, Norris, Patillo, Robbins, Schaffner, Watson, Zimmack.

AUTHORS AND TITLES

MASTERS' THESES

The titles of theses are arranged in alphabetical order by names of authors. Each listing includes the name of the author, the title of the thesis, and the department.

Acker, Duane C. Aureomycin, lysine, and methionine supplementation of corn-soybean oilmeal rations of various protein levels for growing-fattening swine. Animal Husbandry.

Allos, Hazim F. Influence of available nitrogen on the amount of symbiotic nitrogen fixation. Agronomy.

Bailey, Stanley Carl. Direct design procedure for two-hinged arches of constant section. Civil Engineering.

Banach, Patricia Anastacia. Estimation of genetic differences in the physiological response of mice to total body X-irradiation. Genetics.

Barker, Loren Otto. Factors affecting work experience programs in the smaller High Schools of Iowa. Vocational Education.

Barson, Fred. A low temperature dilatometric study of some rare earth metals. Physics.

Bartow, Josephine Alice Rusher. Selected management practices and need for homemaking education of three age groups of rural non-farm homemakers. Vocational Education.

Beavers, Irene. Vocational interests of certain Home Economics Extension personnel. Vocational Education.

Bell, Gordon Russell. Physiology of the chemosynthetic autotroph Thiobacillus thiooxidans. Bacteriology.

Bichel, Darwin Carl. Development and performance of a corn cob processing machine. Agricultural Engineering.

Blackmore, David W. Relationships between rate of growth, leanness and organ weights in swine. Animal Husbandry and Genetics.

Bloss, Donald Ralph. Relationship of certain factors to problems of seventh grade pupils. Vocational Education.

Blue, Marts Donald. Orientation of silver fibers developed from silver bromide crystallites exposed to plane polarized light. Physics.

Boehnke, George Emmanuel. Opinions of members and leaders concerning the effectiveness of awards in the 4-H program in Iowa. Economics and Sociology.

Boehnke, Roger Harvey. Winter movements and covey composition of the Eastern Bob-White, Decatur County, Iowa, 1952-1954. Zoology and Entomology.

Bonnett, Joan Latherow. Fluctuations of expenditures for living with changes in incomes of Iowa Farm Business Association families, 1950-1952. Home Management.

Borchers, Curtis Edward. Kinetics of the Cerium (IV) - thallous reaction in the presence of chloride. Chemistry.

Borduin, Wilfred George. Substituent effects on the spectra and ionization constants of diaroylmethanes. Chemistry.

Bose, Ajoy Kumar. Sensitivity of F-tests. Statistics.

Brandsaeter, Erling. Growth of psychrophilic bacteria in raw milk. Dairy Industry.

Brennan, Robert H. Assimilation of $C^{14}O_2$ by Saccharomyces cerevisiae in the formation of amino acids. Bacteriology.

Brooks, Owen Arthur. Sex differences in proportions and area evaluation of certain equal-size forms. Psychology.

Brown, William Galen. Economic instability and choices involving income and risk in livestock production. Economics and Sociology.

Bruns, David Lee. Employee morale and the judgment of group opinions. Psychology.

Burzlaff, Henry August. Quick curing of mixed fertilizers. Chemical Engineering.

Busjahn, Selma Marcene. Problems and experiences in home furnishings reported by Iowa high school girls in vocational homemaking departments. Vocational Education.

Calamari, James Anthony, Jr. Characterization of some polysaccharides by partial acid hydrolysis. Chemistry.

Canfield, Milton Richard. Driving attitude changes in high school students after viewing a stock car racing film. Vocational Education.

Carroll, William Thomas. Measurement of empathic capacity of nursery school children. Child Development.

Cathey, George W. Factors affecting farming programs of 1952 Arkansas State Farmers in Future Farmers of America. Vocational Education.

Cebula, Richard Sigmund. Constants for the design of continuous steel bridge girders with variable moments of inertia. Civil Engineering.

Clampitt, Richard Roy. Sociometric status and supervisory evaluation of institutionalized mentally defective children. Psychology.

Coad, Roger Dean. Prestressing for highway slabs. Civil Engineering.

Courson, Robert Gene, Slowing-down length of neutrons in hydrogenous media. Engineering.

Cowles, Harold Andrews. Vaporization of water in a two-stage wetted-wall column. Chemical Engineering.

Cox, Constance Elizabeth. Prediction of cutworm outbreaks using light trap data taken at Lethbridge, Alberta. Statistics.

Crunden, Charles Walter. Techniques in the estimation of a Mearns cottontail population. Zoology and Entomology.

Dale, Jim Enoch. Growth of conifers on calcareous soils. Forestry and Botany and Plant Pathology.

Damask, Arthur C. Internal friction associated with precipitation in an Al-Ag alloy. Physics.

Davey, Paul Oliver. Thermal conductivity of nickel. Physics.

Davy, William Curtis. Production of calcium-magnesium phosphate fertilizer in a fuel-fired furnace. Chemical Engineering.

Deal, Bruce E. Kinetics of the reaction between lithium and water vapor. Chemistry.

Debbrecht, Frederick John. Determination of lead in lead sulfide ores. Chemistry.

DeLong, Richard Allan. Effect of krilium and PR-51 on stand establishment at different planting depths in forage crops. Agronomy.

Diehl, Justin Ward. Some derivatives of 10-ethylphenothiazine. Chemistry.

Dooley, John Allen. Scintillation counters for slow neutrons. Chemistry.

Dorsman, Adrian Kryn. Zero-sequence constants of multi-conductor cables. Electrical Engineering.

dos Santos, Aldo Franklin. Phosphorus content of corn plants as an estimate of soil phosphorus availability. Agronomy.

Douce, Lowell Richard. Probing live hogs of different ages to evaluate carcass quality. Vocational Education and Animal Husbandry.

Downes, William L., Jr. The Sarcophaginae of Iowa with special reference to the identification of females. Zoology and Entomology.

du Toit, Schalk J.v.N. Analysis of cattle ranching in the Eastern Kalahari, Union of South Africa. Economics and Sociology.

Edwards, Richard Edmond, Jr. Analysis of thorium-aluminum alloys. Chemistry.

El Banna, Abdel Rahman Safwat. Effectiveness of recurrent selection for plant characters in sweetclover, Melilotus officinalis Lam. Agronomy.

Ewen, Richard Lee. Measurement of the thermal conductivity and specific heat of nonmetallic solids by a transient method. Mechanical Engineering.

Ferguson, Donald Paul. Validation of the Iowa State College temperament schedule for discriminating athletic competitors. Vocational Education.

Field, Forest Arlen. Effectiveness of laminated liquid-solid radiation shielding. Engineering.

Ford, John Joseph. A titrimetric determination of thorium. Chemistry.

Fortney, Cecil Garfield, Jr. Cleaning sanitary pipe lines in-place. Food Technology and Dairy Industry.

Foss, Sally Jean. Flavor and functional properties of untreated, oiled and thermostabilized eggs after storage at 34°F. Foods and Nutrition.

Gard, Vernon William. Relationships between certain socio-economic factors and size of High Schools in Iowa incorporated towns of less than one thousand population. Vocational Education.

Giltner, Robert Francis. Petrology of the Morrison limestones of central Colorado. Geology.

Girtner, Darrel Dean. Analysis of continuous arches. Civil Engineering.

Goche, Leo Nicholas. Relationship of interests and temperament traits to survival in engineering curricula. Vocational Education.

Graf, Gerard E. Effect of some mitotic poisons on CO_2 fixation in roots. Genetics.

Grantham, LeRoy Francis. Kinetics of chloride exchange in aqueous chloride-tetrachloroplatinate (II) system. Chemistry.

Green, Robert Ware. Soil moisture as influenced by cropping practices and meteorological conditions. Agronomy.

Hall, William Franklin, Jr. Continuous countercurrent liquid-liquid extraction of monazite rare earths. Chemical Engineering.

Halter, Albert Nelson. Changes in the organization and productivity of farm resources in Iowa agriculture, 1910-1950. Economics and Sociology.

Hamilton, James Edward. Implications for adult education in agriculture from responses of participants in the veterans farm training program in the central region. V. Methods of improving instruction. Vocational Education.

Hampton, Richard Owen. Comparative pathogenicity of pythiaceous fungi on corn. Botany and Plant Pathology.

Handy, Richard. Petrography of selected southwestern Iowa loess samples. Geology.

Hartel, Paul. History of the Iowa Industrial Education Association. Vocational Education.

Harvey, Dorothy McDonald. Graphic displays and legends for teaching crafts in home demonstration and adult education. Applied Art.

Heemstra, Frank William. Thermionic work functions of some rare earth borides. Physics.

Heer, John Frederick. Directional accuracy of farm price predictions published in the Iowa Farm Outlook Letter (July 1, 1948, to July 1, 1951). Technical Journalism.

Hennemuth, Richard C. Growth of the crappies, Pomoxis nigro-maculatus (LeSueur) and P. annularis Rafinesque in Lake Ahquabi. Zoology and Entomology.

Hertzberg, Grover Robert. Effect of moisture content, assembly time and gluing pressure on shear strength of hard maple joints formed with Liquid-hide glue. Forestry.

Herum, Floyd Lyle. Comparison of corn harvesting methods. Agricultural Engineering.

Hilton, James Lee. Effects of mercurial compounds on the malic dehydrogenase of Myrothecium verrucaria. Botany and Plant Pathology.

Holloway, Albert L. Factors influencing viability of bovine spermatozoa. Veterinary Physiology and Pharmacology.

Hoover, Dale Max. Economic analysis of price support proposals for corn and oats. Economics and Sociology.

Hunter, Donald James. Derivatives of production surfaces and marginal coefficients for economic analysis of fertilizer application on red clover hay. Economics and Sociology.

Jacobs, Edgar Max. A set of maximum likelihood estimates of the marginal rate of substitution. Statistics.

Jaselskis, Bruno. Polarography of vitamin $B_{12}r$ and $B_{12}a$. Chemistry.

Jones, James Thomas, Jr. Radiations from cerium[141]. Physics.

Kelton, Leonard Alexander. Evaluation of characters for genera and subgenera of the Lygus complex (Hemiptera, Miridae). Zoology and Entomology.

Kirk, Lee K. Packaging of nursery stock for shipment to retail markets. Horticulture.

Klonglan, Eugene DaWayne. Factors influencing the fall roadside census of the ring-necked pheasant (Phasianus colchicus Linnaeus) in Winnebago County, Iowa, 1952. Zoology and Entomology.

Kniseley, Richard N. Response of photographic emulsions to light intensities in prism and grating spectrographs. Chemistry.

Korbitz, Frederick William, Jr. Effectiveness of sand-boron-carbon mixtures for radiation shielding. Engineering.

Krieguer, Rosemary Louise. Certain factors related to choice of friends by tenth-grade girls. Vocational Education.

Kwolek, William Francis. A statistical comparison of the relative importance of variables used in evaluating European corn borer, (Pyrausta nubilalis (Hbn.)), damage and infestation. Statistics.

Leupold, Hazel Alice. Managerial implications of home-freezer use by farm families in Story County, Iowa. Home Management.

Lewis, Charles John. Development of improved pig starters. Animal Husbandry.

Lewis, Dorothy Booth. Relation between selected variables of family living and personal and social behavior of childhood. I. Children's perceptions of certain family controls of behavior. Child Development.

Lewis, Robert Wells. Tensile properties of metals in the inelastic range of stress. Theoretical and Applied Mechanics.

Little, Morris Clifford. Leadership qualifications of advisers of Negro 4-H club boys in Georgia. Vocational Education.

Littlefield, Sarah Wells. Technique for measuring understanding of pattern alteration by college students. Vocational Education.

Lodge, James Robert. Influence of aureomycin on in vitro cellulose digestion by bovine rumen microorganisms. Animal Husbandry.

Low, Roger Dean. Symmetrical deformation of circular cylinders possessing transverse cylindrical aeolotropy. Mathematics.

Luce, Gordon Raymond, Jr. Effect of some thiouracils on the growth of a fish, Lebistes reticulatus (Peters). Zoology and Entomology.

Lyle, Mary Frances. College students' choice of dress designs when matched to people's faces and drawings of those faces. Textiles and Clothing.

McCart, Gerald Davis. Soil use in Tama County, Iowa. Agronomy.

McKee, Dean Elgar. Scale associated with decreasing and increasing costs in cash grain farming. Economics and Sociology.

Macy, Bruce Wendell. Structural forces affecting future export supplies of agricultural products in Argentina and Australia. Economics and Sociology.

Maki, Wilbur R. Economic framework for financing cooperatives. Economics and Sociology.

Martens, Clarence Clifford. Educational achievement of eighth grade pupils in certain town and one-room rural schools in Iowa. Vocational Education.

Martinek, Harold. Development and preliminary evaluation of a test of mechanical ingenuity. Psychology.

Maxson, Georgia Rae. Measured personality changes with situational stress. Psychology.

Meshadani, Mahoud Hassan. Estimating the factor loadings by the maximum likelihood method. Statistics.

Meyer, Joan Callaghan. Reduction of selected types of frustration in children through the creative use of materials. Child Development.

Morrill, John Barstow. Prairie flora on the Missouri River bluffs of western Iowa. Botany and Plant Pathology.

Mosing, Lionel Wadell. Differences between normals and abnormals in the perception of serially distorted common objects. Psychology.

Nadler, Marion Ronald. Preparations and properties of calcium zirconite. Ceramic Engineering.

Nelson, Linda Jean. Present and preferred kitchen facilities of selected rural women of Turrialba, Costa Rica. Home Management.

Nelson, Norman Meinecke. Alfalfa seed and forage production in relation to boron fertilization on certain Iowa soils. Agronomy.

Norris, Dale Melvin, Jr. Insects as possible vectors of the oak wilt organism, Endoconidiophora fagacearum Bretz. Zoology and Entomology.

O'Herron, Rosalie Ellis. Development of a training program for student employees in a college food service. Institution Management.

Olson, Keith William. Variations of electrophotoluminescence phenomena with frequency of applied field. Physics.

Ose, Odale Jennings. Uncompensated consequential costs and alternative methods of compensating people damaged by flood control reservoirs. Economics and Sociology.

Papadopoulos, Demetri Constantine. Effects of warmup treatments on psychrophilic bacteria in pasteurized milk. Dairy Industry.

Pattillo, Walter Hugh. Preliminary histochemical studies on Eimeriae of chickens. Zoology and Entomology.

Pauls, John Frederick. Effect of selection of experimental units on experimental error. Statistics.

Perez, Silvia Lopez. Problems in the handicraft program of the Extension Service in Puerto Rico with recommendations for solution. Vocational Education.

Phillips, Donald Lee. Investigation of stresses and deflections in a corrugated metal pipe culvert under a high earth fill. Civil Engineering.

Phipps, Philip Lowell. The half lives of some short lived, low Z nuclei formed by photonuclear reactions. Physics.

Phipps, Robert Gene. Prediction of physics achievement in Clinton High School. Vocational Education.

Pippett, Lloyd Anderson. Evaluation of industrial arts subjects in East High School, Sioux City, Iowa. Vocational Education.

Plaisted, Robert LeRoy. Field plot techniques for estimating onion yields. Horticulture.

Pletke, Leon Ray. Temperature distribution in a metal cylinder containing a heat source. Engineering.

Poulsen, Jenniev Jorgensen. Resources for rural living in the economic areas of Utah. Home Management.

Quiambao, Carmen Sanchez. Children's perceptions of certain affectional family relationships. Child Development.

Reiling, Theodore Paul. Virus diseases of geraniums. Horticulture.

Reuber, Herbert W. Arteriography of the cyclic estrual changes in the internal genitalis of the cow (Bos taurus). Veterinary Obstetrics.

Rhetta, Henry Stevens. Effects of using audio-visual aids in teaching hand tool safety in seventh grade industrial arts. Vocational Education.

Roberts, Charles Yantis. Effects of calcium and phosphate supplementation on growth performance and skeletal composition of growing-fattening swine. Animal Husbandry.

Robbins, Russell Lee. Efficiency of the Ohio Game Flushing Bar under Iowa conditions. Zoology and Entomology.

Rogness, Milton Lander. Recommended use of architectural acoustical materials for the control of noise within existing single family frame dwellings. Architectural Engineering.

Rohlf, Marvin Eugene. Variability of commercially produced meat and bone scraps. Animal Husbandry.

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Samvik, Ulla Ingegerd. Effect of different levels of dietary protein and calories on nitrogen balance of rats. Foods and Nutrition.

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Schark, Allen Edward. Factors related to cooking quality in potatoes. Horticulture.

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Zimmack, Harold Lincoln. Distribution and biology of Perezia pyraustae Paillot, a parasite of the European corn borere, Pyrausta nubilalis (Hubner). Zoology and Entomology.

Zink, Charles E. Predicting type of employment from school records of machine shop students in Sioux City. Vocational Education.

PUBLICATIONS OF MEMBERS OF THE STAFF OF THE IOWA STATE COLLEGE FOR THE ACADEMIC YEAR 1953-54

Certain summaries and indices are of interest in a survey of the publications of members of the staff of an educational and research institution such as the Iowa State College. The publications are listed in alphabetic order under the names of the senior authors. Junior authors are also listed alphabetically with cross reference to senior author.

SUMMARY

Number of individuals listed	699
Number of publications	698
Number of publications with joint authorship	413
Number of publications with single author	285
Number of departments or fields represented in publications	44
Number of individuals who serve as editors or on the editorial staff of one or more scientific or technical periodicals	30

The individuals thus serving are: Ayres, Bolton, Brosier, Buchanan, Burroughs, Davis, Douglas, Dwelle, Fassel, Getty, Gilman, Gould, Gowen, Hartley, Hazel, Heady, Heer, Hooker, Kehlenbeck, Kempthorne, Kutish, Lunden, Melamply, Parks, Ross, Shull, Sprague, Tintner, Twogood, Weber.

INDEX TO PUBLICATIONS BY DEPARTMENTS OR FIELDS

The numbers which follow the names of the departments refer to the index number of the alphabetic list by authors.

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Agricultural Engineering: Total 27 - Numbers 15, 26, 27, 45, 46, 47, 48, 85, 140, 260, 261, 262, 263, 264, 309, 320, 321, 361, 362, 450, 451, 452, 476, 477, 572, 573, 613, 654, 693.

Agronomy: Total 83 - Numbers 1, 4, 10, 24, 43, 49, 84, 85, 87, 88, 101, 122, 128, 143, 149, 195, 200, 201, 212, 219, 220, 221, 224, 229, 241, 242, 243, 244, 245, 246, 247, 248, 281, 297, 309, 310, 323, 327, 337, 338, 359, 368, 382, 383, 384, 385, 389, 401, 426, 427, 465, 485, 486, 511, 520, 535, 545, 546, 547, 552, 554, 555, 559, 560, 561, 562, 571, 581, 586, 611, 614, 622, 631, 640a, 659, 664, 676, 678, 679, 680, 682, 683, 686,

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Ceramic Engineering: Total 1. Number 152.

Chemical Engineering: Total 19. Numbers 3, 5, 6, 7, 8, 34, 35, 99, 107, 119, 120, 138, 139, 365, 398, 471, 472, 473, 595.

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Economics and Sociology: Total 57 - Numbers 30, 37, 38, 39, 44, 105, 106, 124, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 354, 355, 356, 357, 376, 377, 386, 387, 388, 443, 444, 445, 446, 447, 448, 487, 488, 489, 515, 536, 537, 538, 575, 576, 577, 578, 621, 641, 642, 643, 646, 647, 677.

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English and Speech: Total 3 - Numbers 440, 441, 691.

Foods and Nutrition: Total 8 - Numbers 95, 96, 97, 225, 286, 442, 630, 640.

Forestry: Total 3 - Numbers 424, 449, 454.

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Geology: Total 1 - Number 665.

History and Government: Total 10 - Numbers 125, 252, 290, 291, 292, 464, 506, 507, 508, 540.

Home Economics Education: Total 3 - Numbers 111, 117, 685.

Home Management: Total 1. Number 453.

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Landscape Architecture: Total 2 - Numbers 635, 636.

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Technical Journalism: Total 3 - Numbers 462, 463, 510.

Veterinary Anatomy: Total 1 - Number 258.

Veterinary Medicine and Surgery: Total 4 - Numbers 16, 118, 379, 528.

Vocational Education: Total 6 - Numbers 77, 102, 666, 667, 668, 674.

Zoology and Entomology: Total 97 - Numbers 20, 25, 40, 41, 50, 51, 52, 79, 86, 89, 90, 91, 92, 93, 94, 103, 137, 151, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 190, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 207, 208, 209, 210, 211, 215, 253, 256, 303, 305, 320, 324, 325, 344, 404, 405, 406, 413, 416, 420, 422, 431, 432, 433, 434, 457, 504, 505, 509, 529, 532, 541, 542, 563, 567, 568, 574, 616, 637, 673, 695.

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